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CONTENTS.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER XI.

THE KEYLESS MECHANISM.

122. This complement of the modern watch, so much in demand now, and, it must be confessed at the same time, so useful and agreeable, is getting so much in favor that its manufacture and construction is well worth saying a word about. Even now there is still a pronounced mistrust against it in a considerable part of the public, and there are even many respectable watchmakers who cannot resolve to advocate a keyless watch.

The keyless mechanism, though, is much more than a mere toy, or a convenience to the wearer. It is useful in many directions. In the first place, it affords the possibility of winding a watch, and of setting its hands, at any time, and in any place, because these operations do not require the opening of the case, while the winding or setting of any other watch must be done while the body is perfectly at rest, and is impossible in a carriage or on horseback, or even when walking. It cannot be done except under cover, and at a place free from dust, while a keyless watch can be treated in the open air without any fear of rain or dust. All this is more than a mere convenience, because it insures the continual service of the watch during a voyage, when the wearer seldom finds a moment of rest for winding his watch, and in these rare moments may forget to do so, or may have forgotten to take the key with him, and it is sufficiently acknowledged that a watch is doubly important when you are travelling.

123. Another advantage may be expected from the employment of the keyless mechanism, and I venture to say that it is also a very important one. The rotary motion required for winding a keyless watch takes place in a plane vertical or at right angle to that of the balance. This is a complete guarantee against the detrimental effects of the bad, but very frequent, habit of the wearers of watches, of moving not only the key, but also the watch when winding it. This practice, it will readily be understood, involves a sudden rotary motion of the movement in the plane of the balance, and which is repeated ten to twelve times till the operation of winding is completed. If, in the best case, this careless treatment does not result in direct injury to the acting parts of the escapement, it causes at least deviations of rate in a lever watch by violent banking, and those irregularities, which nobody can account for, often discredit a watch in the opinion of its owner, and are often ascribed to a want of skill or care of the repairer to whom it has been intrusted.

124. A very important consideration of the keyless mechanism is the greater durability of the cases, and their interior remaining better preserved from injury and deterioration. The oft-repeated opening wears the rims and joints of the case, and, besides, there is a necessity of not too hard shutting for the case of a key winding watch, which does not exist with regard to a keyless one. This latter may shut

more closely, and thereby protect the watch more efficiently against dust, etc.

125. The necessity of opening the case of a key-winding watch at least once every day admits the direct entrance of dust. The key also, in the majority of cases, is a very active agent for the introduction of filaments and impurities of all kinds, owing to the bad practice of carrying the key about in a waistcoat pocket which nobody thinks of cleaning.

126. For the purpose of studying and comparing the different keyless mechanisms, it will be indispensable to classify them into certain groups, lest the great variety of these contrivances could not be conveniently inspected.

The greatest part, and in fact almost all keyless watches may be divided into two principal categories:

1. Those with which the setting of the hands is done by devices arranged on the winding arbor and shifting on the same.

2. Those who accomplish this result by means of a rocking plate.

127. The last mentioned class, indispensable for fusee watches, is of a more delicate nature, and requires a more careful execution. The former, therefore, is more resorted to, especially in Swiss watches. In considering this first class of keyless mechanisms a subdivision may easily be established between those where the hands are set by pulling the winding knob a little outward, and those provided with a push-piece for putting the hands in motion.

128. This latter class, in the majority of cases, are executed with the so-called kregnet-action, that is, they wind the spring when the knob is turned to the right, and perform a click action without any effect when the knob is turned the other way, thus affording the advantage that any inconsiderable effort for turning the knob the wrong way can not do harm to the mechanism. The kregnet click, however, is not an essential feature of this form of keyless mechanism.

129. The winding knob, in the majority of keyless watches, is connected by a square or other adjustment with the winding pinion, the arbor of which passes through the pendant, the pinion part being within the rim of the case. By this arrangement the barrel arbor, on which the operation is to take place, is situated vertically, while the pinion stands in a horizontal direction, and these two moving parts, therefore, must be connected by an angular gear. In most keyless watches this gear is composed of a straight pinion and a contrite or crown wheel. These, however, constitute a very imperfect transmission of force, because the teeth of the contrite wheel, being cut in the radial direction, can only agree in one point of the action with the direction of the pinion teeth, viz., when the side of the tooth is in the line of centres. During the part of the action which takes place before and after the line of centres, the pinion tooth works against the outer or inner edge of the tooth, which is certainly not an advantage for both parts. The detrimental effects of a gear of this kind will be the more considerable with a pinion of low number, because its teeth lead through a more extended angle.

130. For these reasons it is preferable to employ a conical gear, as offering the best conditions for a regular and smooth transmission of power, and for the durability of the parts. A conical pinion, too, can be executed much stronger than a straight one. There is, indeed, almost an impossibility of practically executing a conical wheel and pinion of perfectly theoretical shape of teeth, but in the way they are commonly made they are quite fit for service, and far superior to the straight pinion and contrite wheel.

131. One of the best keyless mechanisms, on account of its simplicity and durability, has the following general features:

The barrel arbor has at its upper end the ordinary square, and on this square is adjusted a large wheel, as large, indeed, as the size of the watch allows of, or, which is the same, nearly the size of the barrel. This wheel is in gear with another wheel of about two-thirds its size, which is concentrically connected with a conical wheel below the upper plate. This latter wheel is set in motion by a bevel pinion, the arbor of which extends through the pendant of the watch, and has a rifted button at its end outside of the pendant. One of the two flat wheels on the top of the upper plate has at the same time to perform the service of a ratchet, by means of a properly shaped click and spring. This is the fundamental principle of the oldest stem-winding watches, but many improvements have been made on it.

132. For the purpose of setting hands, devices of various kinds may be connected with the previously mentioned parts. The oldest plan of this kind was the following: The winding pinion had a lengthwise motion, and upon pulling the knob a little out, the toothed part of the pinion came out of gear with the bevel or crown wheel, and by means of a lever a small crown wheel was pushed in gear with the minute wheel or another wheel connected with it. The small crown wheel was adjusted with a pipe into the inner part of the axis of the winding pinion, either on a square or on the round axis, having one side flatted about one-fourth of its thickness. The pipe of the wheel, in this case, had a steel pin screwed into its side so as to project a little in the hole, thereby getting sufficient hold on the flatted side of the axis to prevent the wheel from revolving on it, only allowing it a sliding movement in the direction of the pinion axis. (Fig. 32 shows the situation of the parts with the knob pulled out.)

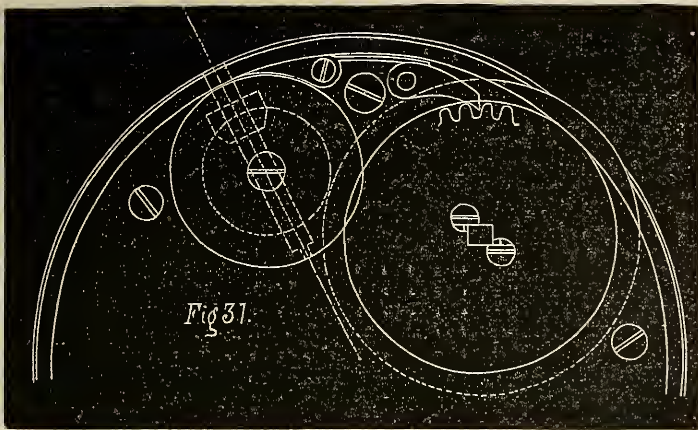


Fig 31.

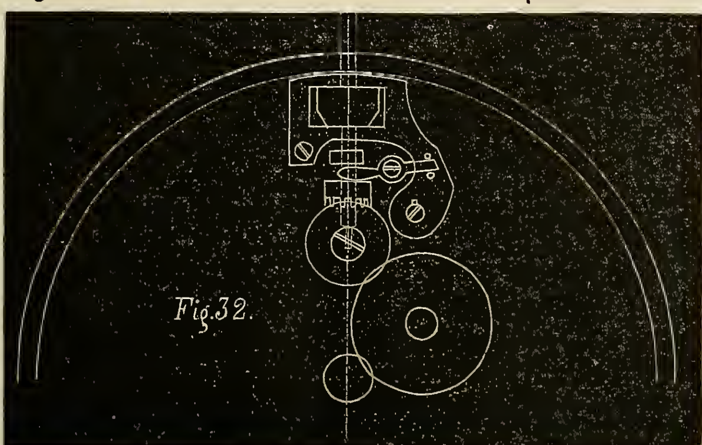


Fig.32.

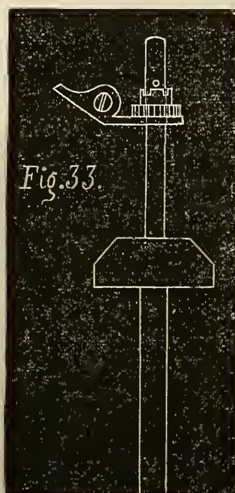


Fig.33.

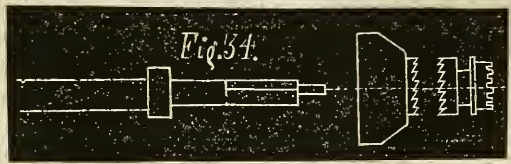
133. Another plan was as follows: There was a small pinion adjusted to the inner round end of the winding pinion arbor, and freely turning on it. The minute wheel geared into a similar wheel, having another row of contrite or crown teeth, and these teeth were constantly in gear with the little pinion on the winding arbor, so that these two parts were following the movement of the motion work when the watch was going. This little pinion was kept in its position by a bridge, and had a small pipe projecting towards the end of the winding axis, and this pipe had two rectangular cuts across its face, forming thus four recesses, broad and deep enough to receive a pin fastened in a hole drilled across the extremity of the arbor. Thus, by pulling the knob and winding pinion out, the pin, when entered into one of the cross cuts, made the pinion follow its motion, and thus imparted the movement to the motion work. By pushing the knob back to its former position, the motion work became disconnected, and the winding action was in gear as before.

134. This way of setting hands, certainly very simple and reliable, was found objectionable, because the knob, when pulled out for setting hands, was often left in that position by careless wearers, and the watch, having then to move also the winding pinion with its considerable friction, was quite unable to perform

the increased task, and stopped altogether. This was a drawback which has essentially produced mistrust against keyless watches, and finally it has led to dropping the device of pulling out the knob for setting hands.

135. Another plan has found much favor, and may be said to answer the purpose very nearly. The winding parts are exactly the same as described, with the only difference that the winding pinion is fitted loosely on a round axis, the inner end of which, as far as it projects from the winding pinion, is square. On this square a little steel tube, with a square hole, is adjusted, loose enough to move with ease up

Fig. 34.



and down the square. The face of the winding pinion and the corresponding face of this tube are cut with ratchet teeth, forming exact counterparts of each other. A gearing, acting in a notch round the periphery of the tube, keeps the two parts constantly connected with each other, so that the winding pinion participates in the motion of the winding axis.

136. When the setting of the hands is required, a small button or push-piece projecting from the case near the stem, is pushed in and causes the spring to slide the tube downwards on the square. The other face of the tube has a small set of contrite teeth which, by this movement, come into gear with the minute wheel itself, or another small wheel connected with the same. At the same time the ratchet teeth of the tube are drawn out of action with those of the winding pinion, so that this latter does not follow the movement of the axis, and when the setting has been done, the button, released from the pressure, allows the spring to bring the tube back to its former position ready for winding.

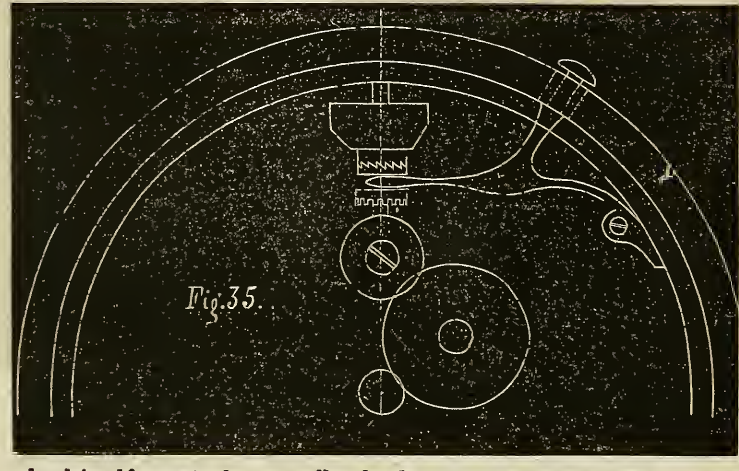
137. There is a secondary advantage in this arrangement, inasmuch as it prevents any damage to the winding parts and clickwork in case of any one turning the winding knob the wrong way, because, in this case, the two ratchets produce the effect of a so-called kregnet-key.

138. Nevertheless, objections have been raised also against this system, because the side opening in the rim of the case for the passage of the button was thought a means of letting dust, etc., penetrate into the movement, and because the projecting button may, under unfavorable circumstances, be forced in while the watch is in the pocket.

For these reasons, much skill and sagacity was spent on other methods of setting the hands in motion.

139. One of them consists in a rather complicated arrangement of the bow of the case, establishing the connection with the motion work when the bow is put down. The advantages to be expected by this contrivance are very doubtful, since the bow may be accidentally put down in wearing the watch, thus bringing it to a stand-still. Besides, many people have the commendable custom of always putting the bow down when laying a watch flat on a table, in order to prevent the polish or engine turning being scratched. This, of course, would lead to the same result.

Fig. 35.



140. Other contrivances have been made with keyless hunters, to the effect of having the push piece protected by the front cover of the case, and projecting from the periphery of the bezel. This push-piece, when pushed inward, causes a part of its spring to get hold at the outer edge of the bezel, and from this moment the winding ceases, and the motion work is and remains in connection with the

winding axis. This hold of the spring and push-piece is released by shutting the case, and every part is in its former situation. This plan answers excellently for every purpose, but if the hands are set without shutting the case afterwards, which some people do when coming home or going to bed, it will evidently stop.

(*To be continued.*)

[The preceding chapters of this Essay were published in Vol. II. of the JOURNAL, the interruption having been caused by the illness of Mr. GROSSMANN. It is hoped that his new Essay may be ready by the time the present one is completed—probably in three or four numbers.]

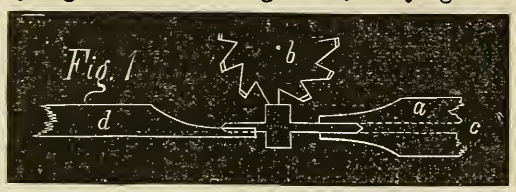
Forming Pinions by Machinery.

The perfection of the beautiful machines which are used for this purpose cannot be sufficiently admired. The exactitude of their performance (under the guidance of experienced operatives) contributes much to the excellent character of the performance of machine-made watches over the same quality of hand-made movements. In this department of the factory operations the fact is particularly noticeable, that there is yet remaining a field for improvement in the manufacture of steel, the best obtainable metal showing a want of uniformity in character. The same lot, selected with the greatest care and judgment, will sometimes be found not identical; there being a want of that absolute homogeneous character which is essential, and particularly so in factory work. In using hand tools in turning upon dead centres by the bow and graver, there is a better opportunity to detect the character of the material operated upon, for the sense of touch, both by the bow hand and the hand holding the graver, becomes highly educated by practice; but the factory automatic lathe gives no such indication as the work progresses; the article must be completed before inspection shows the defects.

For pinions, Stubb's wire furnishes the best stock, showing less of the objectionable eccentricities of texture than any other, and consequently stands foremost in market. The proper size is selected for the contemplated pinion, and cut up by a special machine into suitable lengths, and these pieces have each end pointed or centred, by being seized by the exterior in the jaws of a self-centring chuck, and the projecting end turned to a point by a tool with the cutting edge at an angle with the line of the lathe. These pointed centres form the basis for holding the pinion in all subsequent operations upon it, so that all its parts are perfectly concentric with these two points. The next operation is to place one of these blanks between the centres of a self-acting lathe, which turns up the arbor, and roughs out the pivots. A full and complete description of these little self-acting lathes would be intensely interesting to the mechanician, but would require a number of the JOURNAL to fully describe. They are employed largely in all the turning operations in the factory. A verbal description of what these lathes do, is the most that can be attempted. The cutter, unlike the screw lathes of the machine shops, is in the rear of the work operated upon, and the stock which holds it has a motion parallel to the lathe bed or line of the lathe, and is moved along by a wheel and worm-gear. The extent of its excursion along the work can be limited to any required extent, and the instant that limit is reached it stops and the tool retires slightly from the face of the work, and commences a retreat back to the point of commencement, when a second cut a trifle deeper is taken. The cutter is not held immovably in contact with the work, as in the machinist's lathes, but is held to it by a spring of the necessary strength, so that really the tool is somewhat yielding, as in the case of holding it by the hand. This freedom prevents, or at least has the tendency to prevent, accidents to the work which is being operated upon by these automatic motions, which are all produced through the agency of cones and levers. There is also an arrangement by which the operator, if necessity requires it, can, without changing the speed of the lathe, reverse these motions; he can by hand run the cutter back to the starting point, when it will begin its journey again, or he can move it partially backward or forward. This is allowable, because the driving power is communicated to the machine by friction contact; in fact this is the usual mode of transmission. In most of the machines, the ease with which the amount of resistance is regulated by this mode, gives it a preference above all others; in tapping holes

for screws, for instance, the force of contact which turns the tap may be so nicely adjusted by this means, that any considerable resistance —an amount sufficient to endanger the tap—will cause the parts to slip, thus saving the tap, and preserving the thread from being broken. These self-acting lathes occupy about a square foot of space, and although of the most perfect workmanship in all their fittings, are, for their size, massive; in fact, the mass of material must be sufficient to prevent the slightest amount of tremor or unsteadiness—a fault which would be fatal to great accuracy.

The blank pinion wire being now suspended between the female centres of the lathe arbor, and the stops upon the lathe adjusted to produce the proper length of shoulder, the machine is set running, taking off cut after cut until the requisite thickness for the arbor remains; the blank is then reversed, and the other end turned in the same manner. It may be stated that the position of the cutter can be adjusted in its holder, or rather the cutter itself is movable by screws, so as to give the correct position of the cutter vertically. After the arbor is formed, the pivots are turned down to nearly their required size, and the blank is ready to be transferred to the dividing engine, in which it is placed between centres, not by the points, but held by the arbor itself, which, it will be remembered, is concentric with them. It is necessary to be thus supported to endure the force necessarily applied to cut the spaces between the leaves of the pinion. The mode by which it is held between the arbors is simple and ingenious, which is sufficiently illustrated by Fig. 1. *a* is a strong arbor, carrying at its



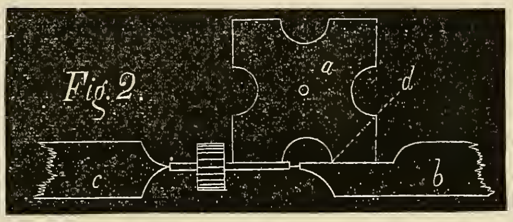
rear end the usual steel division plate, its entire length being pierced with a hole, *c*, through which a plunger passes for the purpose of pushing out the pinion after being cut; for the hole in the nose of the arbor is a slight taper, so that the action of the revolving cutter, *b*, tends to drive it in more and more, and thus insure its being carried with the arbor when the division plate is moved. The short end of the arbor merely lies in a half hole in the arbor, *d*, which is so cut away as to allow the cutter to travel in that direction quite beyond the pinion, as the superior length of arbor permits its excursions sufficiently in the opposite direction. The whole arrangement of the parts is built upon a sliding bed, which allows it to travel horizontally beneath the revolving cutters, three of which are successively brought into use to complete the pinion. These cutters are supported by mandrels, which are themselves supported by a cylinder revolvable about its own axis, so that each cutter can in turn be brought into action upon the pinion blank while the others remain idle. The first cutter is simply a saw, which cuts the space between each leaf of the pinion at the base; the second roughs out the curve of the leaf to its proper shape; the third gives the finishing and final form to it, the operator shifting the division plate and sliding the blank under the cutter for each leaf of the pinion. After being completed, a slight blow upon the plunger forces it out, when it is ready for hardening and tempering, which is the next operation.

After being tempered, the next process is to grind and polish them, and here comes in the service of what is technically called "wig-wags," which are reciprocating polishers running in guides, and actuated by a crank and pitman, or an eccentric. The pinion polishing machine is as complicated as the cutting engine, and only an illustration of its principles will be attempted. The principal parts consist of a reciprocating rod, which is given its back and forth motion by a crank and pitman, the rod running in guides just above the bed in which the pinion rests in half hollows, which support it by its arbor. This bed is kept up in contact with the polisher by a spring beneath, so as to insure a constant pressure upon it. To the reciprocating rod is fixed, by suitable and very convenient means, a strip of metal, its edge planed to exactly correspond with the space between the leaves of the pinion; this slip, charged with stone dust and oil, is set vibrating, and the machine is so constructed that it will make a given number of vibrations between the leaves, and then the pinion is automatically moved forward one tooth, and after making a complete revolution in this manner it stops and waits for another pinion to be put in. The forms given to these grind-

ing and polishing tools have the same care bestowed upon them as upon the cutters which produce the pinion leaf, and the utmost pains is taken to insure a constant adherence to the primary and mathemathical form assumed. After grinding, the oil and stone dust is thoroughly brushed out by a revolving brush and dry lime, and a soft-metal polisher substituted, charged with Vienna lime and oil, and the same process repeated, which method of finishing the pinion gives excellent results. From this they go back to the turning lathes and have the pivots turned down to a gauge so little above the required size that the grinding and polishing them will complete the perfect measurement.

The next step is to grind and polish the arbor and pivots, and here the wig-wag polisher is the instrument for this and all kindred operations. At Fig. 2, *a* is a cross-section of the

Fig. 2.



polishing block, which is an inch square, more or less, and some six inches in length, the far end of the polisher being screwed to a straight rod of a foot or so in length, which is attached by a universal joint to the end of a horizontal pitman, to which a crank gives reciprocating motion. This arrangement of the polisher allows of its being rotated, to bring a fresh surface to the work as occasion requires; it also permits a sliding motion, parallel to the axis of the pinion, so that all parts of its length may be reached, or it may be turned up quite out of the way, and also allows it to be brought in contact with the face of the pinion, which is rapidly rotated while being ground and polished, of course carried by a dog, not necessary to represent in the figure to understand the principle of operation. To keep the polishing surface always parallel to the axis of the pinion, it is necessary that the surface of the arbor, *b*, upon which one face of the polisher is constantly in contact, should remain always intact; to accomplish this, along the surface, *d*, is set a sapphire, which suffers no abrasion by the stone dust and Vienna lime used for grinding and polishing the arbor of the pinion. In use the reciprocating block is guided and manipulated by the fingers of the operator, the smooth rod which connects it to the pitman, siding freely between them, and by which means also additional pressure may be applied when necessary, although the weight of it is considered sufficient in most operations.

Pivots are polished and ground in the same manner, except that the outer end of the pinion arbor is supported by a centre rest of thin steel through a hole in which the chamber or bevel of the shoulder rests, allowing the full length of the pivot and the face of the shoulder to project sufficiently to be operated upon. In grinding down the pivots in this process, they are constantly tried for size by Dennison's split gauge, and the grinding is continued until the size is so nearly approached that, in the judgment of the operator, the final polish will complete its reduction. While in this lathe, the ends of the pivots are rounded and polished by a slip of Arkansas stone and a boxwood stick with Vienna lime. At this stage of the process the pinion is ready for such fancy turning as the character of the watch to which it is to be applied requires. The subsequent operations, such as under-cutting the leaves, oil stop grooves behind the shoulder, etc., are all done by skilled mechanics by hand, the work being shellacked up in the usual way.

The U. S. Watch Factory have some new wheel cutting machines, or pinion cutters, whichever they may be called, that are certainly admirably arranged for cutting the bevel gear for the new stem-winding wheel work which they are now producing. The blank for the bevel wheel or pinion being secured upon an upright arbor, which moves only by the revolution of the division plate attached to it, and the cutters arranged upon a sliding bed to travel across the blank at such an angle with the upright as will give the desired bevel to the pinion or wheel.

It seems hardly possible to arrange a mode of construction that can give more perfect form and finish to pinions than the one described. Any want of truth developed in the process of hardening and of tempering is eliminated by turning up the pivots afterward, and the subsequent grinding and polishing the pinion leaves, with the arbor as a centre of support, which is

itself concentric with the pivots, insures also perfect truth in the pinion. The great care bestowed upon the forms that are given to the grinding and polishing tools to insure their conformity, as far as possible, to the theoretical curves which have been assumed for the pinion leaves, is the secret of the small amount of power lost in its transmission through the whole train. Also in the polishing machine, the arrangement of the parts is such that any number of vibrations desired can be given between each leaf of the pinion, thus affording the opportunity, on the same machine, to give the highest possible finish to such pinions as are to be used in the higher grades of movements. The use of machines of the class described, is a direct growth from the absolute necessity felt, by the watch manufacturers, that some means must be resorted to by which perfect work could be done by unskilled operatives. Skilled labor, in this branch of manufacture, was not to be had, and the time necessary to educate, or even import it, could not be spared. The uncertainty of action in human machines; the bare possibility that, in an emergency, when their services were most needed, they might become possessed with an idea that their services were absolutely indispensable, and that any demands, however unreasonable, which they might make, must be complied with, led those who risked their capital in the adventure to place their trust more upon the perfection and faithful performance of machines than upon the uncertain and capricious character of operatives. The result has been the production of watch movements of a quality and in quantities which, although not equal to the desires of the managers of these establishments, are yet far, very far, ahead of what they would have been able to produce by any other plan in the same length of time. The success of the past points steadily and surely to a future that will far surpass, in the perfection of its productions, anything that hand labor can do for a corresponding price.

The present condition of mechanical watch manufacture is but the first few revolutions of the great wheel which will ultimately drive a whole train of constantly accelerating machinery, and which will turn out productions that will fully satisfy the critical demands of this progressive age.

Watch Repairing.—No. 1.

BY JAMES FRICKER, AMERICUS, GA.

To the "veterans" of the trade, it will, no doubt, look like a piece of presumption for any one to attempt to lay down rules for watch repairing, or to say that this or that is *the* way to repair watches. Now, I admit all this, and if I was writing especially for their benefit, it would not only appear so, but would actually savor much of egotism, to say the least. I do not even claim that my views are the *best*, but shall give the best advice and instruction that I am capable of, and shall more particularly address myself to that class of workmen who have not had the advantage of a good instructor, and to many of whom works on Horology are unknown, and who look to the Horological Journal for all the information that relates to their especial calling, outside of actual experience. To all such the establishment of the Horological Journal has been a godsend, and none of us are so old or experienced but what we have derived much benefit from a perusal of its pages. There is no class of artisans or mechanics in this country who stand more in need of a journal devoted to their especial interests than do the watchmakers and jewellers, and I am proud to say that we have, in the American Horological Journal, one that in every way deserves our individual and united support, not only in subscribing for it, but by contributing to its columns such matter as may be of interest to the trade. Every good workman can certainly write something that will be of value and interest to the majority of its readers. There are those who are adepts at pivoting, others in jewelling, springing, etc., etc. Now, let any one who has some peculiar method of doing any particular class or kind of work, and knows the same to be good, give the trade the benefit of such knowledge, and by so doing we will all gain something, and no one will lose anything. I shall tell my way of doing some things, and if any one knows a better way of doing the same things, I shall be glad to see an account of it in the Journal.

It is a well-known fact, that the majority of the watch repairers in the United States are not first-class workmen by any means, and it is to be hoped that they will be vastly improved by carefully reading and *studying* the valuable

articles that appear in the HOROLOGICAL JOURNAL. There are, of course, a certain class, called "botches," who can never be induced to improve themselves, and are a curse to our trade; but as we cannot get rid of them, they must be endured. They "blow their own horns," and not unfrequently, for a time at least, succeed in making the public believe them to be far superior workmen to their more modest neighbors, who are in reality first-class artisans. This, of course, is annoying, but they usually find their level after a while. To this class my advice will be as "pearls cast before swine," but, as before stated, the rising and *young* watchmakers will thankfully receive any instructions and advice from their more experienced brethren. When I was learning my trade, I would have given a good share of my small salary to have had the reading of some such periodical as the HOROLOGICAL JOURNAL, and to all those who feel as I then did, I know that what I write will be of interest. This much by way of preface, and to explain why I may describe some very common or ordinary methods of doing various things.

The first thing to do, when you are going to repair a watch, which we will suppose to be an English lever, is, of course, to take it out of the case, then carefully examine the balance to see if it runs true, and examine the end shake and also the side shake of the pivots; then examine the pallets, fork and scape wheel, banking pins and guard pin; hold the watch in the left hand, and turn the balance with the left forefinger, so as to bring the roller jewel *outside* of the fork; then, with the tweezers, held in the right hand, see if the scape wheel teeth, when resting on the locking face of the pallets, will force the outer end of the fork (when the banking pins are near the outer end of the fork) back against the banking pins, *after* you have moved the fork so that the guard pin presses against the roller, as it not unfrequently happens that the scape wheel teeth are slightly worn on the end, and are, consequently, too short, which will be indicated by the guard pin remaining against the roller after placing it there, and there is not power enough exerted on the pallets by the scape wheel to ordinarily drive the watch, in which event you will have to put in a larger scape wheel. Sometimes the pallet jewels are broken, or the corners need polishing. Again, both the locking and impulse faces are cut, and need polishing, or new ones may be required. After thoroughly examining the escapement, take off the cock and remove the balance and examine the balance staff, pivots, hair-spring and cock jewel, roller and roller jewel; examine the hands and hour wheel and see if the latter has too much or too little shake; now take off the dial, examine the depthing of dial wheels, see if the pin for the minute wheel is tight and the right size, and if any of the teeth in the dial wheels are bent; let down the main-spring; if the barrel arbor is long enough to allow you to hold it with a key, do so, and carefully raise the click and let the spring unwind; if not, place the pin vice on the fuzee arbor and hold it with the left hand, with lower plate up, and then remove the third bridge, take out the third wheel, and then let the spring down; now examine all the end shakes and side shakes, take out the barrel, remove the pins, and carefully examine every jewel and hole in the watch; then examine the pinions, pivots and wheels—all with a glass—and see if any of them are worn. If the teeth are worn in any of the wheels, either put in a new one or reverse the old one. If a pinion is much worn the only safe way is to put in a new one. If a pivot, you must either put in a new pinion or pivot, or else *turn down* the old one and re-polish it, and, in a plain watch, bush up the hole; if a jewelled watch, put in a new jewel. You will frequently have to turn down the centre and fuzee pivots and bush the holes, as they, especially the centre holes, are so thin that they cut the pivot. In bushing the centre and fuzee holes, always leave the bush as *long* as possible; the reason for this was fully and succinctly explained in the recent articles on friction, and which, by the way, are very interesting and instructive.

Now, after having examined all the train, take the fuzee apart and see if it does not want a new click or ratchet, or other repairs; also examine the barrel and see if the main-spring is of the proper width, strength, and length. After taking out the main-spring, put the arbor and lid back again, and examine its "shakes." If the holes are worn you must bush them, and you may have to turn the arbor pivots true also.

If the barrel is "spread" it must be closed, for which purpose a valuable tool is now in the market called a "barrel closer," one of which every watchmaker should have. Next, see if the barrel runs true on the arbor, which you can do by holding the arbor in your cutting plyers and turning the barrel slowly, which will show you which side is too high. Correct this by spreading the lid slightly on the high side (when lid is up) and taking a little off from the other side. See if all the pillars are in fast, also dial frame feet. When taking the watch apart carefully notice all the screws and see if any of the threads are "stripped;" if so put in new screws. Not only see if any of the jewels are broken, but see if they are loose; peg them out, and see if they are polished inside. Sometimes the balance-staff holes are too large in the hole; at others the holes are not polished, or are worn down on one side; again they are too thick, scarcely allowing the pivot to protrude, in which event the shoulder will rest in the cup and materially affect the running of the watch, if it does not cause it to stop altogether when in certain positions. Too much care and attention cannot be used in making a thorough examination of every part of the watch, *before you do any work at all.* When a watch is left to be "put in order," never do any work on it until you have carefully examined it in every part, and if you have agreed to repair the watch for any stipulated price, make *all the repairs needed,* even if the work is worth much more than you have agreed to do it for. In other words, if you agree to put the watch "*in order*" for a certain price, do so; on the other hand, if nothing is said about the price, and you find, after "due examination," that it will cost more than you have reason to suppose that the owner would like to pay, do nothing to it until you can see him and explain the trouble. Many men, who would think themselves insulted if their integrity or honor were called in question, are so very *economical* that they are quite willing to take advantage of a technicality to get two dollars worth of work done for one dollar, and the only sure way to avoid misunderstanding is to adhere to this rule.

This leaves us now with the watch all in pieces, carefully examined, and with our minds made up as to what we are going to do with it, which will be treated of in the next number.

Marine Chronometer Balance Springs.

In the second volume of the Journal was published a series of articles signed "Horologist," which embodied the mathematical theory of the balance spring, and in the present article we propose to make a few remarks on the construction of the balance springs used in marine chronometers.

Fine cast steel, on account of the peculiar properties it possesses of being manipulated into elastic forms, is the material from which these springs are generally made, although many attempts have been made to find a substitute for it, on account of its liability to be affected by magnetism, and the inherent danger it possesses of being ruined by rust when exposed to the unavoidable damp atmosphere a marine chronometer is often subjected to. The Jurgensens, of Copenhagen, have experimented very extensively with gold as a material for balance springs, but none of their chronometers having gold springs maintain the same steady rate as those having steel ones. Other firms and individuals have spent much time and money trying to discover an alloy of metals that would combine all the advantages of steel, and have none of its disadvantages, but so far their endeavors have not been crowned with success. Some experimenters have tried glass as a material for balance springs, and the published rate of one made by Dent, of London, that was tested at the Greenwich trials, is tolerably good; still the extreme brittleness of glass, although it may have been manipulated in the most skilful manner, prevents its general use for this purpose, and there is yet sufficient room for inventors to try their powers in this direction.

The most of the steel from which balance springs were formerly made came from India, and was analogous to that peculiar quality of steel Damascus sword blades were made from. It is first drawn into wire by some of the usual methods of drawing steel wire, and afterwards annealed and passed between two steel rollers, one being perfectly flat and the other having grooves of a size and shape corresponding with the spring wire desired to be made. This wire, after being repeatedly annealed and reduced to nearly the proper size, is made clean and bright, and finished in a draw plate having the hole

made of sapphire, which gives it that beautiful smooth and regular surface that is so much desired for this purpose. The wire is then rolled on to spools, and in this condition it is sold to chronometer makers. The best quality of needles may be annealed and drawn into spring wire in the manner we have described, the most formidable obstacle being the expense of making the sapphire hole in the draw plate to finish the wire; but in an emergency it may be reduced to the proper size and strength by drawing it carefully between two pieces of oil stone.

The springs are formed into shape by wrapping a piece of the prepared wire around a form having spiral grooves cut in it by a small screw cutting lathe, or with a cutting engine. The ends of the wire are fastened by screws, which hold it in position while the spring is being hardened. These forms are usually made of brass, but we could never understand the philosophy of using it, unless it was because they were easier made and the grooves easier cut in brass than in any other metal. In our opinion steel should be used for this purpose, because, in heating the spring previous to its being hardened, the brass expands in a larger ratio than the steel of the spring, and consequently it produces an undue strain, which cannot in any way be beneficial to the spring, and may be injurious. Fine steel is not much more difficult to work than brass, and we think it worth the extra trouble to use it in making these forms.

The prepared steel-wire from which the spring is to be made is fastened at one end of the block by means of a screw, and, as we have already stated, is wound tightly round the bottom of the grooves and fastened to the form at the other end by means of another screw, which should have a left-hand thread, because tightening up the screw will draw the wire closer against the form, while using an ordinary right-hand screw would make the wire loose. It is the usual practice to bend the elbows at the ends of the spring into shape after the spring has been hardened and tempered, but we can see no good reason why this could not be done in many instances when the spring is soft, and suitable recesses made in the form to receive them. This plan would insure the entire spring being the same hardness when finished, while in springs made by the usual methods the hardest parts are the round corners where the elbows are made.

The spring wire, having been carefully fastened on to the form, must now be prepared to be subjected to the action of heat, which should be applied to it slowly and regularly, and no air be permitted to come in contact with the surface of the steel when it is under the influence of heat, or when it is in the act of being cooled. This precaution is necessary to prevent the steel from blistering or changing its bright color. Some workmen use pastes of various compositions to effect this purpose, but probably as good and as safe a plan as any is to place the form with the spring around it in the inside of the bowl of a large common clay pipe and pack it well with pounded charcoal, the object being to prevent any air coming in contact with the surface of the steel. As the steel is covered up and hidden from view, a small piece of the same size of wire that the spring is made from should be placed in a convenient position among the particles of charcoal, so that it can be taken out and examined to ascertain when the spring has reached a cherry red color; and when this color has been reached the whole mass is plunged into oil and made hard. At this stage the spring, although it is hard, will be found to have a sufficient amount of elasticity to admit of being handled, and after it has been thoroughly cleaned it is blued over an alcohol lamp in order to give it proper elasticity, and also to put a skin on the surface to protect it from rust when exposed to the atmosphere.

Such is a brief description of the most approved method of making a marine chronometer balance spring from steel. Some makers varnish their springs with collodion to more effectually prevent rust, and others have gilded them in order to effect the same purpose; but it is obvious that covering the steel with any foreign substance will affect its elasticity, and the most reliable chronometers are those that have no coating of any kind on the surface of the spring except the blue that is upon it. The very curious phenomenon, which is practically illustrated in the liability which chronometers, having had new balance springs applied to them, have of accelerating on their rate for the first few months, and finally, without any apparent cause, settling down to a steady rate, will be noticed in a future article.

Sand Blast.

There are strong probabilities that, in the not far off future, the application of some modification of the "sand blast," which was mentioned in a previous number of the JOURNAL, will come into quite general use, for the purpose of superficial ornamentation of metallic articles. That it will be especially adapted to the wants of plate workers is almost certain. Its adaptability to many of the arts of civilization is clearly indicated by Prof. Eggleston's report of even the few tests of its power which he was permitted to make at the Fair of the American Institute. He says:

"The sand blast proved to be so much more powerful than could have been imagined, that it was necessary to entirely rearrange the experiments after they had been commenced. The minerals chosen were corundum in crystals, from Delaware Co., Pa., a piece of emery from Chester, Mass., composed of a mixture of corundum and magnetite, a pebble of topaz of the variety known as Goute d'Eau, a large topaz pebble, colorless and transparent, with a large cleavage face, and a black diamond. The following table gives the results of these experiments:

Minerals.	Time Exposed.	Weight in grms. before.	Weight in grms. after.	Loss in weight.
Corundum Crystal....	30 seconds	1.49	0.22021	1.16979
Emery, Chester, Mass.	1 minute	16.65	11.6968	4.9532
Topaz (goute d'eau)..	1 "	2.097	0.1263	1.9707
Topaz pebble.	1 "	9.774	7.6241	2.1499
Black Diamond	3 minutes	1.2607	1.2235	0.0372
" "	5 "	1.2235	1.1738	0.0497
" "	8 "	1.2607	1.1738	0.0869

"In a former experiment, a hole nearly ¾ of an inch above, and ½ an inch below, was bored through a corundum crystal from Ceylon, one half an inch thick, in eight minutes. The weight of this crystal previous to the operation was not taken, but the crystal is preserved in the mineral collection of the School of Mines. In the emery from Chester a large hole was made, in which pieces of corundum project, showing that the blast acted much faster on the magnetite than on the corundum. A conical hole was made in the topaz pebble, the point of the cone being quite sharp. The microscopic examination of these specimens, showed that they all presented the same general appearance. The emery was worn away in a manner very similar to that which is so often seen on the surfaces of rocks near sand beaches, which are exposed to violent winds, carrying sand with them, and suggested to me, whether more importance should not be given to this agent as a power of degradation, and as the cause of many phenomena in structural geology not hitherto explained. If such effects can be produced by the fan blast in a very short time, is it not likely that the action of the wind at ordinary velocities continued a very long time, will produce much more powerful effects on a large scale, and may we not expect that a hurricane would produce effects similar to that produced by the injector machine with steam? The peculiar chatoyant lustre of many minerals I was able to produce at will, on any mineral possessing cleavage, by a few moments' exposure to the blast. It seems probable that many of the rounded faces of minerals which have this lustre, may have been produced in this way, and that many of those rounded surfaces noticed on minerals which have no cleavage may be traced to this cause. It seems more than likely, too, that some of the deep furrows existing in rocks composed of layers of different hardness, may have been produced, partly at least, by the agency of sand. I greatly regret that, though I continued my experiments up to the moment of closing the building the last night of the Fair, I was not able to carry them out as I first intended. The specimens exhibited, however, show that sand whirled by the wind, even at a moderate velocity, is a much more powerful agent than we generally have supposed, and that at the velocity of a whirlwind even the hardest rocks will be worn away with very great rapidity."

It may be possible to apply this mode of abrading surfaces to "matting" the several parts of watchwork, previous to gilding them, so as to give that granular appearance so peculiar and desirable to gilded surfaces. This is now done by the use of revolving wire brushes, which certainly perform the work in a satisfactory manner, and so long as any mode of doing a thing is satisfactory—that is, profitable—no producer will ever trouble himself to adopt improvements simply because they are such; only when some *new* rival establishment threatens to

annihilate his business will he adopt, as a trade necessity, the latest and best methods of production. The constant advance of discovery gives new claimants for public favor one great advantage over old concerns, by the adoption of the latest improvements in their line of manufacture, whereby they can successfully compete with experience, capital, and reputation. This constant action and reaction between the old and the new ways keeps the world advancing. Principles that were once thought applicable to only one class of results, are constantly being discovered useful in new and unexpected directions, and in many cases with far greater benefits than those which first suggested their application to any purpose of art.

One of the indirect uses of the principle of the "sand blast," and quite foreign to the design of the inventor, is beautifully illustrated in its adaptation to engineering purposes in the excavation for the massive piers constructing for the suspension bridge between New York and Brooklyn, and a brief description may be of interest in this connection. As the piers require the utmost stability, the "bed rock," or solid substrata, must be laid bare to receive them. This rock is covered to a greater or less depth with "drift," or loose material, sand, gravel, boulders, rock, etc.,—a mass of debris which must be removed, and modern engineering science has adopted the use of "caissons" for this purpose. The principle of their construction is easily understood by supposing a shallow apartment of any desired shape, open at the bottom, constructed in a manner and of such material as will insure the requisite strength; usually a massive frame-work of timbers forms a platform upon which the masonry is built. Through the centre is an opening through which access is had to the interior of the caisson, either by winding stairs or by a steam hoist, and also through which pipes are laid for the admission of air, gas, etc., as well as for raising to the surface the material excavated. The interior is also supported by a system of timber braces, which no superposed weight can crush, and the ponderous caisson thus freighted sinks upon the bottom. To allow excavation below the caisson, the water must be forced out. To do this it is necessary to close the bottom of the well, and construct a lock that will permit entrance and exit. The external air is then forced within it, through the proper pipes, by steam air-pumps, or "compressors," until the pressure is sufficient to force out the contained water, which is kept out by the same means and which also furnishes the workmen a constant supply of fresh air.

There are some peculiar mechanical arrangements necessary to the working of this system. To allow of entrance and exit to the caisson, where this immense pressure is constantly in action, there is built at the bottom of the well a small chamber, or "lock," as it is technically called, of boiler iron, of the same strength as the other parts of the structure. Into this chamber the door (3 feet by 2) opens from the well; also another in its side, of the same size, permits egress from the "lock" into the caisson. The descent of 75 feet below the surface of the water is made by stepping into an open basket suspended at the top of the well from a wire cable, which can be wound up or down by a small engine on the pier. On the occasion of our visit, we were let down to the bottom speedily and safely. On arriving there, the attendant signalled with a hammer upon the iron door, and was answered from within by the roar of air escaping from a pipe overhead. After waiting about five minutes, the escape of the compressed air within the "lock" had so diminished the pressure that the door could be opened, and we stepped from the well into the ante-room of the great caisson. The door was then closed behind us, and we were hermetically sealed in a wrought-iron can barely capable of holding us six humans, who were packed like sardines in a box, and grimly illuminated by a single candle, sconced upon the wall of our iron prison. The situation was not cheerful in the extreme, nor were the results which the imagination pictured, pleasurable, in the event of anything happening to anything connected with the machinery. The engineer gradually turned the pressure upon us, letting the compressed air of the caisson into our small apartment, the augmented pressure forcing the drum of the ear inward, producing a sensation somewhat similar to that experienced when water gets in the ears of a bather. The roar of the dense air, as it rushes in upon us, at last ceases,—the pressure finally equalling that within the caisson, which permits us to open the other door,—and we step out, reeking with perspiration, into the little

world of diggers, and wheel-barrows, and shovels, and see the dim, shadowy forms of men slowly undermining the dome upon which rests the whole superstructure of the pier. The effects of the condensed atmosphere are curious; hearing is somewhat difficult, and one must get very near a listener to be heard at all. The sensation of one's own voice is the same as if the ears were tightly closed while speaking, and audible whistling is impossible. Living in a pressure of 45 lbs. to the square inch—about the same as the ordinary pressure of steam boilers—does not interfere with muscular action, nor does it seem to affect the circulation or respiration.

The dynamic effect is what we particularly wish to notice in this connection. Through the dome of the caisson there extends up to the outer world iron pipes, 3 inches or so in diameter, the open end of which reaches down near to the surface of the excavated earth, and which are opened or closed by a suitable stopcock. Through them all the loosened debris is discharged upward simply by the outward rush of the compressed air, carrying with it whatever is small enough to pass through the diameter of the pipe. Around the bottom of the pipe, the sand and stone are deposited, after being loosened and broken into suitable size to pass it, and, upon opening the cock, the rush of air carries up the rubbish as rapidly as four men can shovel it about the end of the pipe. The fury of this upward current produces a sound like steam from the escape pipe of a boiler. The effect of this blast of sand is especially evident upon the cast-iron elbow at the top of the pipe, which is put on to direct the outrushing current of air, sand, and stones, at a right angle against a timber target, which prevents it being scattered far and near over the neighborhood. This elbow is of cast-iron, and about three inches in thickness, and this blast of sand and air cuts it quite through in a few hours. Our outcome from this region, after an hour of interesting observation, was effected in the reverse order of entrance. On stepping into the "lock" and closing the door behind us, the compressed air about us is gradually let out to the upper world until its density equals the outer air; the other door can then be opened, which admits us to the bottom of the well, where we step into the basket in waiting, and are quickly drawn up to the world above, thankful that we had safely escaped from beneath the very centre of the pile of granite which the workers below were sinking, inch by inch, to its final seat upon the bed rock.

Emerald; or Smyragdus of the Ancients.

"With verdant light the modest emeralds glow,
Blue sapphires glare, and rubies blush below,
Light piers of lazuli the dome surround,
And pictured mocoes tesselate the ground."
—DARWIN.

"As when an emerald enchased
In flaming gold, from the bright mass acquires
A noble hue, more delicate to sight."—J. PHILLIPS.

Pliny, the historian, says of it, as Holland in his quaint language translates it: "There is not a gem that so fully possesseth the eye, and yet never contenteth it with sacietie. * * * Moreover, the longer and farther off that a man looketh upon emeralds, the fairer and bigger they seem to the eye, by reason that they cause the reverberation of the aire about them to seem greene, for neither sunne nor shade, nor yet the light of a candle, causeth them to change and lose their lustre. Contrariwise, they even send out their own raies, by little and little, so they entertain reciprocally the beams of our eyes; and for all the spissitude and thickness that they seem to have, they admit quietly our sight to pierce into their bottom."

Emerald seems to be a name of Eastern origin, the significance of which is *obscure*, and may have been derived from the Chaldean "*Esmorad*" or the Arabic "*Zamarut.*"

This stone was held in high estimation by the ancients, and to it they attributed all manner of virtues, moral, physical and even medicinal. Pliny states that when Lucullus landed at Alexandria, Ptolemy presented him an emerald, set in gold, with his portrait engraved on it. They have been found in the ruins of Thebes, and ancient writers give accounts of stones of immense size. Much controversy has taken place as to whether the emerald was really known to the ancients previous to the discovery of the emeralds of Peru, some even arguing that those ancient stones found in the East must have been derived from the mines of Peru by way of the Philippine Islands.

There are, however, obstinate facts which seem to show conclusively that the Romans were in possession of real emeralds, which they might have obtained from Upper Egypt, or they may have derived them from the Ural and Altai Mountains, where they are now found. Nero, who was near-sighted, is said to have used an emerald to witness gladiatorial exhibitions. It is hardly probable that Nero used this in the character of a concave lens, as a corrective of the myopia with which he was afflicted, but in the belief, then so prevalent, that even the looking upon an emerald was extremely beneficial to the sight. Could it be established that it was a lens, the invention of spectacles, at least for myopes, would have been anticipated by a thousand years or more.

That the emerald was highly esteemed by the Mexicans and South Americans at pre-historic periods, is proved by the magnificently wrought specimens which Cortes found in the possession of the Incas of Peru. The Aztec rulers of Mexico possessed crystals of rare beauty, which they held in especial estimation, and the Hindoos have ever been especial admirers of the emerald when formed into pear-shaped drops, pierced so as to be worn as pendants for the ear. So essential was it to suspend these and other gems upon the person, that many magnificent stones have been sacrificed to this mania for beads. The gems so mutilated must, for modern use, be cut into two inferior ones.

Emeralds became much more common after the conquest of Peru, and it is asserted that Cortes presented to the King of Spain 100 lbs. of this beautiful stone. It is said that of five stones, beautifully wrought by the Aztecs, which he brought to Spain, he was offered for one 40,000 ducats, by some Genoese merchants, and history relates that the finest one of these, a small cup with a foot of gold and four tiny gold chains attached to a large pearl, to be used as a button, he presented to his bride as a marriage gift. Of the others, one was cut in the form of a rose, another a horn, the third a fish with eyes of gold, and one formed into a bell, with a magnificent pearl for a tongue. That the young conqueror should have given the most beautiful of these gems to any other than the Queen of Charles V. is supposed to have caused that feeling of estrangement between the Queen and himself which proved prejudicial to his future prospects.

The historical accounts of famous emeralds are numerous, and have given rise to endless controversy, from the fact that early records furnish such unsatisfactory details as leave the character of the stones described uncertain. Theophrastus mentions an emerald obelisk of only four stones, forty cubits high, and two by four broad, standing in the Temple of Jupiter. The accounts rest wholly upon the uncorroborated testimony of the writers, but, *if true*, the stones must have been other than true emerald; probably were green jasper, or malachite, artfully cemented together, and perhaps their size wonderfully magnified by these reporters. The Alexandrians were famous for their glass manufacture, and figures of this size may have been executed in some vitreous composition, and represented to credulous visitors as real emerald. Modern science has made sad havoc with many of these famous *gems* of the ancients. The 28-lb. mass of emeralds formerly belonging to Charlemagne has since been ascertained to be "green fluor." Another, deposited in the treasury at Genoa, and which was not to be seen except upon an order from the Senate, on careful analysis has proved to be *green glass.*

It is a fact that some of the antique glass emeralds possess color, lustre, and hardness in a degree far superior to the modern pastes. King, in his history of "Ancient and Modern Precious Stones," says that one found at Rome, that had been recut and set in a gold ring, eclipsed in beauty almost every real stone of the kind he had ever seen. In fact, it is a usual practice there among the gem dealers, on obtaining a fine green paste, to get it recut and facetted for a ring-stone, and as such obtain a high price for it of the unwary *dilettante.*

The most magnificent cut emerald in England is in possession of Mr. Hope, of London. It is perfect in color, weighs six ounces, and is valued at £500. It is supposed to be from Coimbetoor. There are grave doubts of the genuineness of this stone, for its freedom from flaws, as contrasted with the true emerald, is enough to lead to suspicion; for, of all the precious stones, none are so liable to defects as this, it being almost impossible to find among the Peruvian emeralds even a small one, which,

when cut, will be free from flaws. The Duke of Devonshire has a hexagonal prism, weighing 8 oz. 18 dwt., which is two inches long, and its three diameters are $2\frac{1}{4}$, $2\frac{1}{8}$ and $1\frac{7}{8}$ inches. This crystal, from New Grenada, is perhaps the finest in Great Britain, although it is too imperfect for the lapidary's art. In the Royal Collection at Madrid there are some magnificent stones, as large as those in the Duke's collection, and of the first water.

The ancient Romans, as well as the caliphs, probably derived their emeralds principally from the Egyptian and Ethiopian mines. Extensive traces of these works are still to be seen under Mount Zubara, in Upper Egypt. Mohammed Ali re-opened the shafts, and had fifty miners at work, but without success, the mines probably having been exhausted. The Ural Mountains and the East Indies furnish some, but the principal source of supply of emeralds for the whole world, since the discovery of America, has been Peru. Of all the South American mines, those of Muzo, in the Republic of Colombia, are the most extensive and interesting.

Mr. Bunch, Secretary of Legation at Bogota, has furnished much information on these emeral mines, derived undoubtedly from his French colleagues, who are in sympathy with the French Company, who have the entire monopoly of emerald mining till 1874. These mines appear to have been known long before the conquest by the Spaniards, and probably before the discovery by Columbus. The native tribe, called "Los Musos," at the period of the Spanish invasion, possessed large quantities of emeralds, but how they worked the mines is not clear, as they had no iron tools. They at present show unmistakable evidences of having been extensively worked by the Spaniards, both in the open air and in galleries. They were abandoned about the middle of the eighteenth century, but what for what reason no one seems to know. Tradition relates that they were left because the mountains vomited flames which lasted many years. This account seems fabulous, for there are no evidences of volcanic action at or about Muzo. They were not again worked until the Spaniards were expelled by the war for independence; since then they have been let out to individuals and companies.

In 1864, a French company obtained a grant of the mine for ten years, at an annual rental of about $15,000, the Government of Colombia prohibiting the working of any other mine in the country during that time. It is the opinion of the French engineer, Lehmann, who is now director of the mine, that the mountains of Muzo are rich in emeralds. The whole chain, as far as "Lasquez," bear traces of Spanish mining, and as the whole neighborhood is evidently of the same geological formation, the quantity must be inexhaustible. The geological location of the gems in these mountains is exceedingly interesting, having distinct mines at different altitudes. The lower is in a mass of semi-decomposed granite, mixed with ferruginous clay and nodules of wolfram, among which the prisms of beryl are disseminated, rarely exceeding an inch in length, and of a greenish yellow color. Eight hundred yards above is an irregular vein of micaceous clay, which contains the most valuable crystals, of pale green color, and sometimes seven or eight inches in length by two in diameter. At the summit is a vein of dried clay, mixed with arsenical pyrites and beryls of greenish blue, and sometimes a transparent sky-blue color. Most of the emeralds from Muzo are sent to Paris to be cut, where they have been much in demand by the Imperial Court, on account of the color, green, being the color of the Empire.

The emerald and beryl have the same chemical constituents, but usually differ in color, although some so closely approximate the emerald green as to deceive experts. Indeed, the famous stone in Mr. Hope's collection is suspected to be an Indian beryl. Green sapphires also occur which so resemble emeralds as to be difficult to identify. Prases are occasionally met with among antique intagli which, from the extraordinary richness and brightness of the green, cannot be distinguished by the eye alone from Peruvian emeralds. King says that Pliny's account of Nero's smyragdus, "which reflected objects like a mirror from its plane surface," was singularly correct, and attests his accurate acquaintance with the peculiar properties of the gem. A large, flat emerald, if held so as to reflect the light, will assume the exact appearance of being silvered at the back; its green disappears when its plane is brought to a certain angle with the ray of light, and it will seem exactly like a fragment

of looking-glass in the same position, which singular change is not observable in any other colored stone.

The chemical composition of the emerald is:

Silica	68.5
Alumina	15.7
Glucina	12.5
Perox. Iron	1.0
Lime	0.2
Oxide of Chrome	0.3

BERYL.

Silica	67.0
Alumina	16.5
Glucina	14.5
Perox. Iron	1.0
Lime	0.5

Emerald has its specific gravity, 2.7; hardness, 7.6 mohs; acquires positive electricity by friction; crystalline form is hexagonal prism, with double refraction; its color a beautiful green, unsurpassed by any other gem. The Greeks believed that it possessed the property of "assimilating the color of water into which it is thrown to its own color, the stone of middling quality tinging a smaller quantity, the best sort all the water, while the worst only colors the liquid directly over and opposite itself."

The intensity of this "quivering green" was formerly supposed to depend upon the oxide of chrome, but analysis fails to show this connection, and the opinion is expressed that the tint depends on some organic substance, similar to the coloring matter of vegetation. In confirmation of this opinion, emeralds at a low heat become white and opaque, while those minerals colored by chrome remain unaffected.

Emeralds are cut in the square table form, with the edges replaced by facets, the lower surface cut in facets parallel to their sides. Fine stones are set without foil; those of inferior color are surrounded by brilliants or pearls, to enhance the effect.

The rarity of fine emeralds, free from flaws and of fine color, places the price of such stones on a par, if not in advance of, the diamond; perfect ones reaching a price as high as $150 to $175 per carat, while small, imperfect stones will not bring $1.50 per carat. It is quite probable that any considerable increase in the quantity placed upon the market would lower the price, which may occur when the French monopoly of the emerald mines of Colombia ceases, which will be in 1874.

Diamonds.

The fear, or hope, has often been expressed that the discovery of diamonds in quantities might overstock the market and reduce the price; but recent discoveries do not tend to confirm this expectation. A report made Dec. 20, 1871, to the *London Society of Arts*, by T. W. Tobin, who has been investigating somewhat the geological character of the diamond fields of South Africa, gave rise to a lively discussion on the subject. Contrary to general belief, instead of depressing the market value of fine stones, those under a carat in weight had advanced in price; still for large stones, the ancient rule for estimating the price would not hold good, and they could not now be obtained. The rarity of stones of the first water from that locality will also aid in sustaining the present prices. The bulk of all the South Africa diamonds, as yet found, although large in size, are too much off color to compete with first class stones in the market. The black diamond (carbon) so largely used in the Arts for drilling, could be bought for about five francs a carat, but within the last year has gone up to 30 f.

The discovery of the real source of the diamond is as far off as ever. It is quite evident that the material in which they are found, and which is easily disintegrated, was not a true rock, but a more modern formation, something like a conglomerate, and it is yet to be proved that the diamond has a true matrix like other gems. The evidence thus far adduced goes to show that the finds now were only erratic diamonds imbedded in the conglomerate, and this belief is strengthened by the fact that amorphous diamond (black carbon) is not found in connection with the South African crystals; some chemists and mineralogists even go so far as to express the opinion that the diamond is not of mineral formation at all, but a crystallized gum, as amber was a fossilized gum. A proof of which is that they are found of all colors, with cavities and foreign bodies imbedded in them, and that up to this time there was no reliable record that a diamond had ever yet been found in

what might be strictly called a matrix. The only thing surely known was, that the purer the color the less earthy matter it contained, and the more perfectly it would be consumed in oxygen gas.

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Effects of the Unequal Temperature of the Atmosphere of Rooms on Compensated Pendulums.

The communication of "Fairbanks" in the last issue of the Journal, concerning the influence the unequal temperature of the atmosphere in rooms may exercise on the accuracy of the mercurial compensation, leads me to make some further remarks on this subject. It must be admitted by all who have had opportunities of observing the performance of the compensation of pendulums of various constructions, that, in practice at the present day, no form of the mercurial compensation gives any better results, or shows a more uniformly regular rate, than when it is made the same as Graham himself made it, and which is substantially the same as we see in the fine old regulators and astronomical clocks made in London and elsewhere. Nevertheless, it is not safe to conclude, on that account, that this pendulum is free from errors, but, like compensation pendulums of every form, it is an accumulation or a combination of errors; the one error in an imperfect manner counteracting or neutralizing some of the other errors.

If we take two good thermometers, and place one at each end of a seconds pendulum, it will be found that the temperature is generally lowest at the bottom. I have found this difference to vary according to the position in which the clock may be placed, and the materials from which the case is constructed; but as a general rule it will be found that the temperature is slightly lower at the bottom of the pendulum. Several gentlemen, whom I have conversed with on this subject, and others who have expressed their views in writing, seem to favor the idea that this inequality in the temperature of the atmosphere is unfavorable to the accurate action of the mercurial form of compensation; and however plausible and reasonable this idea may seem at first notice, it will not take a great amount of investigation to show that, instead of being a disadvantage, its existence is beneficial, and is an important element in the success of the mercurial pendulum.

It appears to me that the majority of those who have proposed, or have tried to improve Graham's pendulum have overlooked the fact that different substances require different quantities of heat to raise them to the same temperature. In order to warm a certain weight of water, for instance, to the same degree of heat as an equal weight of oil, or an equal weight of mercury, twice as much heat must be given to the water as to the oil, and thirty times as much as to the mercury; while in cooling down again to a given temperature, the oil will cool twice as quick as the water, and the mercury thirty times quicker than the water. This phenomenon is accounted for by the difference in the amount of latent heat that exists in various substances. On the authority of Sir Humphrey Davy, zinc is heated and cooled again ten and three-quarters times quicker than water, brass ten and a half times quicker, steel nine times, glass eight and a half times, and mercury is heated and cooled again thirty times quicker than water. From the above it will be noticed that the difference in the time steel and mercury take to rise or fall to a given temperature is as nine to thirty, and also that the difference in the quantity of heat that it takes to raise steel and mercury to a given temperature is in the ratio of nine to thirty. Now without entering into minute details on the properties which different substances possess for absorbing or reflecting heat, it is plain that mercury should move in a proportionably different atmosphere from steel in order to be expanded or contracted a given distance in the same length of time; and to obtain this result the amount of the difference in the temperature of the atmosphere at the opposite ends of the pendulum must vary a a little more or less according to the nature of the material the mercury jars are constructed from.

I perfectly agree with "Fairbanks" that this difference in the temperature of the atmosphere of a room will generally vary according to its size, the height of the ceiling, and the ventilation of the apartment; and if the difference must continue to exist, that it is of importance that the difference should be uniformly regular. We must not lose sight of the fact, however,

that clocks having these pendulums, and placed in apartments every way favorable to an equal temperature, and in some instances the clocks and their pendulums incased in double casing in order to more effectually obtain this result, still the rates of the clocks show the same eccentricities as those placed in less favorable positions. This clearly shows that many of the changes in the rates of fine clocks are due to other causes than a change in the temperature of the surrounding atmosphere. Still it must be admitted that any change in the condition of the atmosphere that surrounds a pendulum is a most formidable obstacle to be overcome by those who seek to improve compensated pendulums, and it would be of service to them to know all that can possibly be known on the subject.

Any experiments "Fairbanks" may have made will doubtless be very acceptable, but in order to gain as varied and as complete information on the subject as is possible to be obtained, and that the controversy regarding the difference in the temperature of the atmosphere at the two ends of a pendulum should be satisfactorily settled, I would respectfully call upon EVERY READER OF THE JOURNAL interested in the subject, to try, by means of two delicate thermometers, during the summer and a part of the winter months, what difference exists in the temperature of the atmosphere at the top and bottom of their standard clock case, taking special notice if the difference in the temperature be uniformly regular in the summer months, and also during the winter, when the apartment is heated artificially. If the many readers of the JOURNAL feel disposed to respond to this call, and send in the result of their experiments to the office of the JOURNAL about the end of next winter, a mass of reliable statistics would be obtained on the subject, and without a great deal of trouble to any one, that could scarcely be collected in any other manner. I am authorized by the publisher to state that the reports of the various experiments will be published either singly or collectively. Therefore, brother watch and clockmakers, hang up two good thermometers, one at the top and the other at the bottom of your standard clock case, and notice the difference in their readings, how much the difference amounts to, and if the difference between the two be uniformly regular on all occasions, when the apartment is heated by the natural heat of the sun, or when by heat applied artificially. All who feel disposed to comply with this request, or who can offer any suggestion in the matter, will be helping the solution of the most formidable of all Horological problems—the improvement in the construction and compensation of the material pendulum.

CLYDE.

Mechanical Progress.

ED. HOROLOGICAL JOURNAL:

I rarely see anything in your JOURNAL from commercial travellers—"guerillas," as they are sometimes derisively called. For many years, I have followed that honorable calling,—having been promoted from the bench, or descended from it, as you view it, to the road,—and in my wanderings up and down the earth, I have not failed to notice a marked improvement, within the last few years, in the mechanical members of the trade, the watchmakers proper. I well remember the time when, out of cities of considerable size, it was rare to find a young man at the business who had the least idea of what was good work, or the faintest perception of the necessity for good tools. Even in shops of some considerable pretension, no tools or machines were thought needful beyond a few files, cutting and flat plyers, drill-stock and bow, and a common Swiss lathe.

My memory goes back to the time when I found, in a country village in Ohio, a watchmaker who had "squatted" in the corner of the village doctor's office, and at the time of my visit to sell him—no, not him, but his competitor—a few necessary materials, he was busy "topping" the teeth of an old-fashioned balance-wheel (crown-wheel). Some of the present readers of your JOURNAL would never guess the mode by which it was done. He had no lathe, no collet,—no proper appliances of any kind for decent work; and yet, by one make-shift and another, he had managed to gain quite a reputation for good work, which meant simply, that the watches he repaired performed in a satisfactory manner. His method of doing the job I saw him at was this: Upon the pinion of the wheel he shoved a piece of pith, and around this he passed the hair of the bow, and, placing

the pivots in the Fig. 8 calipers, and the calipers in the bench vise, he thus improvised a lathe, in which he was truing up the points of the teeth with a piece of slate pencil. This day of small things is passing away. I see, every day, a growing desire for information as to processes, and a greedy thirst everywhere manifesting itself for the latest and best tools, and the very best materials. Wherever I offer them for sale, the workmen eagerly inquire if I am a practical workman; and when I answer in the affirmative, am invariably beset with questions about methods of working. And if I say I have not been practically in the business for many years, they at once reply, "Well, you have been about among workmen so much you must have seen and learned how this or that thing is done, and can tell me something about it."

This condition of mind shows a creditable advancement in the right direction, and the principal object I have in thus addressing you is to assure you that I attribute this state of things largely to the influence exerted upon members of the trade by the Horological Journal. It has shown good executive workmen that there are principles involved in construction which they had but little considered; and that there are heights yet beyond the present attainments of very many. Young men, who once thought themselves as good as the best, by perusal of trade journals have learned, to a certainty, that they are not yet at the summit of knowledge in the profession, and are stimulated, if they have a spark of ambition, to perfect themselves in an art which, unfortunately, has not hitherto been generally appreciated as being above and superior to mere hand work. Another element may have contributed somewhat to this improved state of things. The demand for greater exactness in the performance of watches has compelled to more careful workmanship. The general introduction, all over the country, of railroads and railroad time-keepers, and the friendly competition among the wearers of watches as to the superior going qualities of each, has forced upon the trade greater attention to critical regulation, and an attention to small errors, which, in times past, would either not have been discovered at all, or, if seen, would not have been thought of any account. The general use of a higher grade of watches has shamed inferior workmen into a desire to be able to do a creditable job upon them; or the fear that customers may, by some means, detect their inability to do fine work, and so lose custom, may have brought about in them the same desire for improvement. Whatever the cause is, the result seems pretty generally accomplished. The stand your Journal took on its first introduction to the trade, as an exponent of the methods, wants, theories, and expectations of practical workmen all over the country, was the best method that could have been selected for the accomplishment of the very result which seems to have been attained; and none could have better met the varied wants of the trade.

There are many young men who are anxious to perfect themselves in the business; they find great difficulties in the way of securing competent instruction; in many instances, the limit of the master's knowledge is soon reached, and when nothing farther is to be learned of him, they become restless, dissatisfied, and, finding few opportunities for working with more competent instructors, they naturally enough conclude that, rather than keep on with a master no wiser than themselves, they may as well start business on their own account; and they hang out a shingle in some small town, take another boy to educate up to their own standard, and thus the manufacture of miserable workmen is perpetuated. I really believe, and certainly hope, your practical Journal will diminish this crop of self-sown tinkers—first, by affording those who are really desirous of more knowledge an opportunity never before offered for obtaining it; and, secondly, by becoming a gauge on which each workman may measure and compare his own attainments with those of his fellows. Pardon me for thus obtruding my views upon you, but I cannot refrain from again expressing the conviction that your Journal has done much toward improving, not only the mechanics themselves, but has also given an impetus to the trade in fine tools and materials.

Peregrinator.

New York City.

Selecting Balance Springs.

Ed. Horological Journal:

I have an idea, and the sensation is so novel that I must speak of it. It occurred to

me a few days since, when selecting a hair-spring, whether it would not be possible to select a proper spring for a balance—that is, a spring which should give it the requisite number of vibrations per minute—by some system of weighing. The notion is, that a certain weight of balance must have a certain amount of hair-spring to give it the proper vibration. If the spring was too thin, or not enough of it, it would weigh too little; and if too thick or wide, the weight would be too great, etc., etc. Now, take a scale beam, with one short arm and one long one, very delicately constructed, so as to turn by a fraction of a grain (it might be necessary to jewel the holes); upon the short end suspend a small scale pan, and let it be counterpoised by the long delicate arm itself. If you place in the pan the balance, with its staff-roller, collar for the hair-spring, in fact all the parts that the spring must oscillate, it is evident that somewhere upon the long arm there will be a point where the spring which gives that balance the necessary vibrations, will counterpoise it. Now, if the long arm has on it some system of graduation, it will be obvious that any other spring of the right diameter of coil, if it counterpoised the balance at the same degree, ought to give the same number of vibrations to the balance as the first one. A lighter balance would, of course, require a lighter hair-spring. If no rule could be formed for the purpose of measurement in this way, it seems to me possible to get up an arbitrary table of numbers by actual trial of springs and balances, which could be used for the purpose of selection, and thus avoid the tedious process of counting vibrations, or measuring the strength of the spring by some machine.

A. F. T.

St. Louis, Mo.

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Long and Short Screw-Drivers.

Ed. Horological Journal:

I am learning to be a watchmaker, and notice a great many strange things around me; but nothing puzzles me more than to find out why a long screw-driver has more power than a short one. I notice carpenters and machinists all use very long screw-drivers for large screws. I have two small screw-drivers, which have handles exactly of the same size, and the points are precisely alike, only the point of one is one and a half inches from the handle, and the point of the other is four inches. I only use one hand on the screw-driver, and I can remove a larger and stiffer screw much easier with the long screw-driver than I can with the short one. I can find no one that can explain the reason to me, and I can see nothing that explains this strange fact in any work on natural philosophy I have within my reach. If you, or any of the readers of the Journal, can give me any explanation I will be thankful to receive it.

E. H.

Hartford, Conn.

[These inquiries of our young correspondent show symptoms of an inquiring disposition, and we would judge that sooner or later he is likely to master many of the mysteries of the horological profession, and also the philosophy of many of the tools used in the various branches of the business. Regarding the extra power we appear to obtain by using a long instead of a short screw-driver, we are inclined to the belief that, in using a long screw-driver, the eye more readily directs the force we apply in a line with the centre of the screw; consequently but little of the force is wasted; but in the case of the short screw-driver, much of this force is likely to be wasted by pressing the screw to one side. If any of our correspondents can offer any other solution of this question we will be happy to receive it.]

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Friction.

Editor Horological Journal:

Through the kindness of a friend in the United States, I am in regular receipt of your Journal, and I always take a great deal of pleasure in reading it; but lately I have been especially pleased and instructed with the very spirited discussion on the subject of friction, and I beg leave to transmit to you a fact connected with our business, that has come under my own observation, and which bears on this question. I am familiar with the details of an old clock which is constructed on the same principle as an ordinary regulator in a tall case. It goes eight days with sixteen turns of the barrel, has pinions of sixteen leaves, and a

pendulum that I would judge weighs twelve or fourteen pounds, while the weight that drives it is very light indeed; in fact, it is only a little brass ornament hanging from the pulley. The pulley and weight together weigh less than one pound. The escapement is the ordinary dead beat one, and does not differ in any particular from those generally in use, except in the scape wheel, which is constructed of the usual diameter and very light, and the parts of the teeth that act on the pallets are at least three times broader than scape wheel teeth are usually made. Now, if friction be proportionate to the extent of the bearing surfaces, the fact ought to be made visible on the action of such a sensitive part of a clock as the escapement. Yet this clock, that has so broad bearing surfaces on the scape wheel, goes, and a twelve or fourteen pound pendulum is maintained in an arc of vibration of $1\frac{1}{4}$ degrees on each side of the point of rest with a weight of less than one pound, while it is nothing to see a fine regulator, with a thin scape wheel, requiring a weight of four, and even six pounds to make a pendulum of the same weight vibrate in the same arc of vibration.

The clock in question differs in no particular point in its construction from the best class of English regulators, except in the broad bearing surfaces of the scape wheel, and I may state that the greatest amount of judgment is displayed by the maker in every detail.

J. WHITELAW.

Edinburgh, Scotland.

Correction.

EDITOR HOROLOGICAL JOURNAL:

I desire to correct a wrong inference on the part of a correspondent, in the June number of the JOURNAL, in regard to a quotation of mine. For the benefit of those who have no copy to refer to, I take the liberty of stating that the quotation in question *does not* refer in any way whatever to the manner of fastening the American lathe to the bench, but only to the sliding *backward* and forward of the head and tail stock on the lathe bed, which has no more a centre of motion than a brick.

I would also like to state, that more surface can be given to the face of screw threads by making the angle more acute. If any given screw thread is cut deeper, more surface is exposed, as well as the angle rendered more acute. Also, if, instead of increasing the depth of the thread, the base of the thread is reduced in thickness, this renders the angle more acute, and, by allowing many more threads in a given length, greatly increases the surface.

B. F. H.

Sag Harbor, L. I.

Answers to Correspondents.

E. L. M., *Defiance, O.*—You seem to misapprehend the idea of a "peg-balance," seeming to think that the additional weight thus given to it is a detriment. Your excellent illustration, comparing it to putting a number of pounds of lead in each shoe, to keep a man from walking more than four miles per hour, should have suggested to you the very purpose for which the balance of a watch is weighted. Were the vital energy of the man so great that he was impelled at the rate of seven miles per hour, in spite of himself, the wearing of weighted shoes would be quite adequate to reduce his speed to four miles, if that was the rate he was *required to go.* You also have some wrong notion of the theory of compensation balances, or else the article you refer to is not clearly written. You say: "Let a man have the care of a watch rated in a safe, the heat of his body would add to that heat, and that a man who is so nice for time as to have his watch properly adjusted, should go in with it in his pocket, and have a thorough test made as to both cold and heat, then the adjustments put out to the public would be of some account, but now they are looked on as bought and paid for, the same as patent medicines. For me, a plain gold balance is far superior to any yet invented."

Plain gold balances for *constant temperatures* are excellent; but either you or the rest of the world are mistaken, if, as you say, the additional temperature of the body vitiates the adjustment, for the very object of adjustment is to have the watch maintain exactly the same rate of going at *any* temperature to which it may be subjected between freezing and blood heat. If you will give the subject a careful consideration, you may see it differently. Just now you seem in the same frame of mind as was the

left-handed man, who insisted that he alone used the *right* hand, and all the rest of the world were left-handed.

F. M. D., *Milan, O.*—The second volume of the JOURNAL, bound, will cost you $3.50, and you will find more *practical* information in it than can be found on the subject anywhere else in print; because it contains, in the form of controversies, communications, and answers to correspondents, an aggregate of experiences which the lifetime of any one workman would not suffice to glean orally.

The Arkansas oil-stone you complain of is too fine grained—the texture of the stone is probably too compact. There is a bare possibility that the surface was finished too fine—ground too smooth. No way is known of changing the quality of the stone; they vary very much in that respect, and many trials are often necessary to get just the thing, which should cut well, and yet not leave a rough surface. Sharp and fine best expresses the requisite qualities. You *might* succeed in bettering yours by re-grinding the face with coarse, sharp sand and water, on a cast-iron lap. The easiest and best way to do this will be to place it on a marble-worker's grinding-wheel, if you have such in Milan, which will produce, in a short time, a new and possibly a better cutting face on the stone.

J. H., *Minn.*—You need make no excuse for asking questions, nor need you have mentioned the fact of your being a subscriber as an apology for doing so, for the JOURNAL is ready and willing to answer the honest inquiries of any one who really desires information. The fact that inquiries are made on any point shows that some one, and perhaps many readers will be benefited by a reply. It has been the ambition of the JOURNAL from the first to be useful to the trade; and, to do the greatest good, it is necessary to know their greatest needs. Questions and answers accomplish both objects in the most direct and satisfactory manner.

The duplex escapement is easily adjusted, when properly made, as they mostly are. You will find valuable remarks and a full description of the escapement on page 113, Vol. II., of the JOURNAL; but if you have not access to the back numbers, it will answer your present purpose to know that when the staff is at rest under the action of the hair-spring, and no force acting through the train, the jewel slit must be in straight line between the staff and escape wheel centres, and the finger or impulse pallet must be placed in position to receive the upright tooth safely upon its face, at the instant the radial tooth escapes from the jewel slit. With the parts placed in these relative positions, the escapement is in condition to its best action, and has the least tendency to "set" under the perturbations incident to carriage in the pocket.

S. D., *Philadelphia.*—Mr. Frodsham being the successor or Arnold, the two names and the inscription A. D. F. m. s. z., which you inquire about, means simply this: "Arnold, predecessor of Frodsham, A. D. 1850;" for in that year he issued what he called "a new series with a new and peculiar construction of the train," and all the subsequent movements were marked F. m. s. z., which was simply a cryptographical method of writing 1850, by substituting the letters of his own name for numerals, with the addition of z. for the cipher or zero—A. D. of course being the abbreviation for Anno Domini.

G. K. L., *Tenn.*—You can prepare very good colored foil for setting stones, by taking *bright* tin foil and coating the surface with a varnish of shellac in alcohol, tinted to the depth of color required by any of the aniline colors that are soluble in alcohol. Apply the varnish with a broad flat brush, it will quickly dry, flatten nicely by passing it between rolls, or by burnishing. The proper material is copper foil, silver-plated, and colored as above.

S. R., JR., *Maine.*—The ordinary refrigerator for house purposes, with the door opening in front and the ice box in the top, will answer every purpose for your use.

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☞ We are requested to state that, in consequence of unavoidable delays in producing the new Lathe advertised in the JOURNAL, they will not be ready for market sooner than three or four months.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For July, 1872.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be added to Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Monday	1	68.77	3 34.64	+.480	6 39 22.82
Tuesday	2	68.73	3 46 04	0.470	6 43 19.37
Wednesday	3	68.68	3 57 16	0.458	6 47 15.93
Thursday	4	68.64	4 8.01	0.445	6 51 12.49
Friday	5	68.59	4 18.52	0.431	6 55 9 05
Saturday	6	68.54	4 28.69	0.417	6 59 5.61
Sunday	7	68.49	4 38.49	0.402	7 3 2.17
Monday	8	68 44	4 47.92	0.385	7 6 58.72
Tuesday	9	68.38	4 56.92	0.367	7 10 55.28
Wednesday	10	68.32	5 5 50	0.348	7 14 51.84
Thursday	11	68.26	5 13.61	0.329	7 18 48.40
Friday	12	68.21	5 21.25	0.309	7 22 44.96
Saturday	13	68.14	5 28 42	0.288	7 26 41.52
Sunday	14	68.07	5 35.09	0.266	7 30 38.07
Monday	15	68.00	5 41.25	0.247	7 34 34.63
Tuesday	16	67.93	5 46.89	0.225	7 38 31.18
Wednesday	17	67.85	4 52.01	0.202	7 42 27.74
Thursday	18	67.78	5 56.58	0.179	7 46 24.30
Friday	19	67.70	6 0 59	0 156	7 50 20.86
Saturday	20	67 62	6 4.04	0.133	7 54 17.42
Sunday	21	67.54	6 6.95	0 110	7 58 13.97
Monday	22	67.46	6 9 31	0.087	8 2 10.53
Tuesday	23	67.37	6 11.09	0 063	8 6 7.08
Wednesday	24	67 29	6 12 28	0.039	8 10 3.64
Thursday	25	67.21	6 12.90	+ 015	8 14 0.20
Friday	26	67.13	6 12 97	− 009	8 17 56.75
Saturday	27	67 04	6 12.47	0.033	8 21 53.31
Sunday	28	66.96	6 11.37	0.057	8 25 49.87
Monday	29	66.87	6 9 69	0.081	8 29 46.42
Tuesday	30	66 78	6 7.43	0 106	8 33 42.98
Wednesday	31	60.69	6 4 58	0 131	8 37 39.54

Mean time of the Semidiameter passing may be found by sub tracting 0.19s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

	D. H. M.
● New Moon	5 6 24.8
☽ First Quarter	13 7 48 2
☺ Full Moon	20 1 53.5
☾ Last Quarter	26 19 19.3

	D. H
☾ Apogee	6 12 4
☾ Perigee	20 1.3

Latitude of Harvard Observatory .... 42° 22′ 48″.1

Long.	H. M. S.
Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	D.	APPARENT R. ASCENSION. H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus	1	6 25 19.73	+23 40 57.6	23 47.3
Jupiter	1	8 25 40.92	+19 48 42.3	1 46.0
Saturn	1	19 20 22.80	−21 56 1.5	12 38.7

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For August, 1872.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be Added to Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Thursday	1	66.60	6 1.14	0.156	8 41 36.09
Friday	2	66.52	5 57.10	0.180	8 45 32.65
Saturday	3	66.43	5 52.48	0.205	8 49 29.20
Sunday	4	66.34	5 47.25	0.230	8 53 25.76
Monday	5	66.25	5 41.42	0 255	8 57 22.31
Tuesday	6	66.17	5 34.98	0.280	9 1 18.87
Wednesday	7	66.08	5 27.96	0.305	9 5 15.43
Thursday	8	66.00	5 20.33	0 330	9 9 11.99
Friday	9	65.91	5 12.11	0 355	9 13 8.54
Saturday	10	65.83	5 3.30	0.379	9 17 5 10
Sunday	11	65.75	4 53 91	0 403	9 21 1.65
Monday	12	65.67	4 43.94	0.427	9 24 58.20
Tuesday	13	65.59	4 33.39	0 450	9 28 54.76
Wednesday	14	65 51	4 22.28	0.473	9 32 51.32
Thursday	15	65.43	4 10.63	0 496	9 36 47.87
Friday	16	65.36	3 58.44	0.519	9 40 44.43
Saturday	17	65 28	3 45 73	0.540	9 44 40.98
Sunday	18	65 21	3 32 51	0.561	9 48 37.54
Monday	19	65.14	3 18.80	0.581	9 52 34.09
Tuesday	20	65 07	3 4.61	0.601	9 56 30.65
Wednesday	21	65.00	2 49.96	0.620	10 0 27.20
Thursday	22	64 93	2 34.86	0.638	10 4 23.76
Friday	23	64.87	2 19.33	0.656	10 8 20.31
Saturday	24	64.81	2 3.38	0.673	10 12 16.87
Sunday	25	64.75	1 47 04	0.689	10 16 13.42
Monday	26	64.70	1 30.33	0.705	10 20 9 98
Tuesday	27	64 64	1 13.26	0 720	10 24 6.53
Wednesday	28	64.59	0 55.83	0.734	10 28 3.08
Thursday	29	64.54	0 38.05	0.747	10 31 59.64
Friday	20	64.49	0 19.97	0.760	10 35 56.19
Saturday	31	64.44	0 1.56	0.773	10 39 52.75

Mean time of the Semidiameter passing may be found by subtracting 0.18s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

	D. H. M.
● New Moon	3 21 45.7
☽ First Quarter	11 17 52 4
☺ Full Moon	18 8 53.3
☾ Last Quarter	25 8 35.2

	D. H.
☾ Apogee	2 14.3
☾ Perigee	17 10.7
☾ Apogee	29 22.5

Latitude of Harvard Observatory .... 42° 22′ 48″.1

Long.	H. M. S.
Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
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Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	D.	APPARENT R. ASCENSION. H. M. S	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus	1	9 7 16.32	+17 52 26.4	0 25.7
Jupiter	1	8 53 15.34	+18 7 32.3	0 11 7
Saturn	1	19 10 54.50	−22 15 58.0	10 27.5

AMERICAN

Horological Journal.

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CONTENTS.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER XI.—[Continued.]

THE KEYLESS MECHANISM.

141. From the foregoing observations some conclusions for the setting hands mechanism may be arrived at, and I always thought these parts ought to be constructed in such a way that:

1st. *The motion work can never come into contact with them by any accidental cause; on the contrary, they should be so arranged as to require a decided act of the wearer to establish their effect on the motion work.*

2d. *After having set the hands, the said mechanism ought to go out of gear with the minute wheel by its own action, and without requiring any care whatever of the wearer.*

These two principles are of the utmost importance for the good and reliable service of the watch, for a watch invariably stops if the keyless mechanism comes into, or remains in gear with the motion work at a wrong time; and a construction which requires a degree of care which not all wearers bestow on their watches, must be called defective, so long as other constructions may be attained without this weak point.

142. That kind of keyless mechanism with which the hands are set by laying down the bow of the case, implies a neglect of both the above principles. Those mechanisms which require the knob being pulled out, and those in which the push-piece keeps hold till the case is closed, are against the second of those principles.

143. There is an arrangement which is entirely free from the above-mentioned objections (138), and applicable to open-faced and hunting cases, in which the push-piece projects from under the bezel, and flat with the outside of the case. Its thickness of about one millim., or a trifle more, allows of its being pushed in with the nail without difficulty. The rim of the bezel in the open face case, or that of the front cover of a hunting case, must be filed through so that the end of the push-piece just fits into it.

It is evident that there is no opening for the entrance of dust, that no pressure from outside can move the push-piece, and the former free position of the setting hands mechanism is instantly re-established by the action of the push-piece spring as soon as the setting has been done. The only inconvenience resulting from this arrangement is, that an open-faced watch of this kind requires the glass bezel to be opened for setting the hands, which is not necessary with the projecting push-piece. But with a well-regulated watch the setting hands is a rare occurrence, and even a little inconvenience in these cases is of no great consequence.

144. The other principal group of keyless mechanisms, those with the rocking platform, will also require some study. They offer some very important advantages, especially for fusee watches, where the fusee arbor, not being stationary, like the barrel arbor of a going

barrel watch, requires an absolute independence of the rest of the keyless mechanisms at any time, except in the moment of winding. Therefore the wheels on the rocking bar or platform, in a fusee movement, must be kept by a spring in a neutral position, touching neither fusee wheel nor motion wheel.

145. Most of these keyless mechanisms have three wheels on the rocking bar, the middle one being the bevel wheel into which the winding pinion gears. This latter requires no prolongation of its axis into the movement, and in many watches it depends only on the bearing of its arbor in the pendant of the case for its support. This, however, is objectionable, and the considerable amount of side pressure which always results from any angular transmission, strongly indicates the necessity of giving the inner end of the pinion a support on the edge of the pillar plate, which is so easy to obtain. A pinion supported in this way allows also of inspecting the bevel gear without having the movement in the case, a convenience of some value. The rocking bar is fastened in such a way that the centre of its oscillatory movement is the centre of the bevel wheel, so that the two wheels gearing into it at both sides remain in regular action with it in whatever position the bar may be. One of these wheels is continually in gear with the barrel wheel on the square of the barrel arbor, to which it communicates the winding action. The other wheel stands sufficiently apart from the teeth of the minute wheel of the motion work, so that it does not touch the teeth of it when the wheel at the other side of the bar is clear out of gear with the barrel wheel. Moreover, it is held at a sufficient distance from the minute wheel by a spring acting on the working bar. (Fig. 36.)

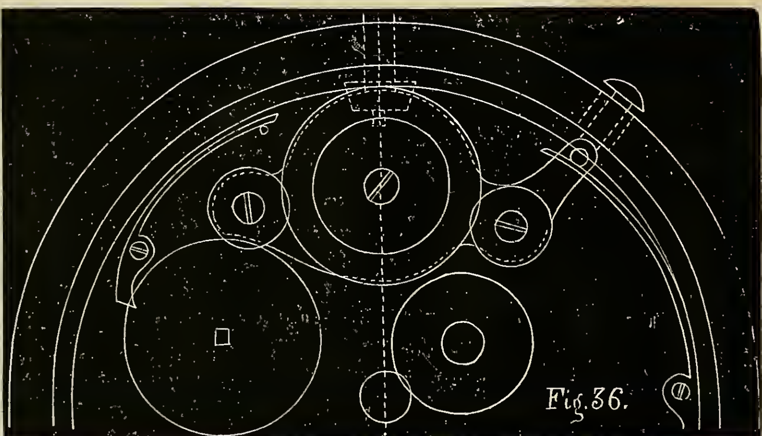


Fig. 36.

146. Setting the hands requires the inverse position of the rocking bar to be established by external pressure on a push-piece, to which the same observations apply as made on this subject before (138–143). The push-piece produces a change of position of the bar, bringing the other wheel on it into gear with the minute wheel, while a banking pin prevents the movement being extended farther than required for a safe depth. After setting the hands, the bar is brought to its former position by its spring.

147. This arrangement has also the so-called Breguet click, and if it is attempted to wind the wrong way, the clickwork prevents the barrel wheel from following the motion in this direction, and the rounded parts of the teeth of the rocking wheel slide over those of the barrel wheel, so that no harm can be done to any part of the mechanism.

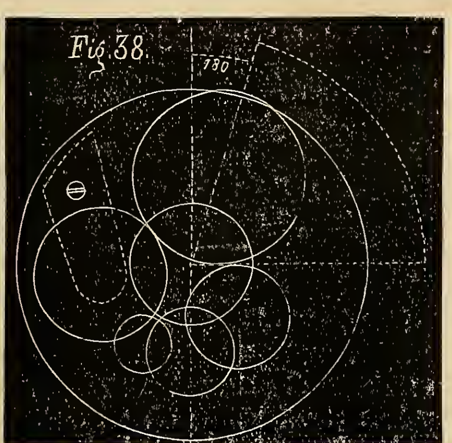
148. In fusee movements, as already explained, this mechanism requires another arrangement, inasmuch as the wheels of the rocking bar must be kept in a middle position between the winding and setting action, which is produced by a properly applied spring. For bringing the rocking bar to act on the fusee wheel, no push-piece is required. Here we see one of the surprising effects of friction, which is a constant and obstinate adversary of the watchmaker. The friction of the small intermediate wheel on its stud on the bar causes this latter to move round the centre of the bevel wheel by the reaction of the gear, as soon as the winding pinion is turned in the right direction. If this friction by itself is not sufficient to throw the wheel into gear with the fusee wheel with the necessary security, a small stiffening spring must be applied underneath the intermediate wheel, in a recess at the lower side of it. For setting hands the usual push-piece must be resorted to. When turning the knob the wrong way, the fusee watch, having no Breguet action, the wheels on the

rocking bar only move freely and without any effect whatever.

149. A beautifully devised keyless mechanism, with rocking platform, is that of Mr. V. Kullberg, one of the first rate London makers. This mechanism has but two wheels, and the motion of the bar is derived from very subtle effects of frictional reaction of the gearing wheels. The only drawback to it is the necessity of a straight toothed pinion and contrate wheel, since the bar does not oscillate round the centre of the contrate wheel. Mr. Kullberg describes his mechanism in the April issue of the *London Horological Journal*, 1869.

150. After the foregoing observations on the nature of these two principal classes of keyless mechanism, and their essential functions, it remains to say some words about the way in which they are applied to the movement.

The movement delineated in Fig. 38 admits,



for hunting watches, the application of the keyless mechanism without the slightest change in its disposition, except setting the pillars a little farther towards the edge of the plate, in order to have the pillar screws free of the large winding wheels. The lower pivot of the three-wheel pinion, also, will have to be set in the pillar plate instead of the bar, because the room at this place will be required for the minute wheel.

If the winding wheels are to be level with the upper plate, this latter must be left so much thicker; a very commendable plan, because it utilizes the additional height required for the winding wheels to give greater length to the axis of the train (60). In any other respect the disposition of the movement and all its parts, is the same, whether it is a keyless or key-winding one.

151. The arrangement of the keyless mechanism in an open-faced watch, on the contrary, is rather difficult, if the winding operation is to be performed at the pendant, which is the most convenient of all the places that might be assigned to it. The pendant of an open-faced watch always corresponds to the XII. of the dial, and if the watch is to have a seconds hand on an eccentric seconds dial, which is the general rule for the watches of our period, the position of the barrel with respect to the pendant can only be altered within very narrow limits, if essential deviations from the principles of constructing the train (53) are to be avoided.

In a well-constructed movement (Fig. 38) the angular distance between the pendant line and the barrel centre, taking the centre of the movement to be the summit of the angle, is about 20°; while in the same movement, when put in a hunting case, the pendant of which is at the III. of the dial, this angle is 90—20=70°, a very convenient distance for the placement of the keyless mechanism, while 20° are wholly insufficient for the purpose.

152. For avoiding this difficulty, several methods have been adopted, and there was hardly any proceeding showing more forcibly the necessity under which the constructor of a watch constantly finds himself, to subordinate his better knowledge to the taste and to the habits of the public. Making the keyless open-faced watches without seconds would do away altogether with the difficulty, since the place of the barrel may then be chosen quite freely; but the public want all watches with seconds.

It has been tried for a considerable period to arrange the dial in another way, so as to have the seconds dial at another place, say at the VIII. or IX. of the dial, but the taste of the public refused the offer, though irreproachable from the constructional point of view. Symmetry of the dial was pronounced an imperative necessity.

In this awkward position it may be called a very ingenious expedient that some manufacturers tried to establish the sacrificed symmetry of dial by adding a date hand to it, symmetrically situated with the seconds hand; but the additional cost of this dial, for which no essen-

tial want was existing, was again an objection.

Others, again, provided the train with an auxiliary fourth pinion, serving merely to carry the seconds hand. This system realizes a sufficient distance between pendant and barrel for the placement of the keyless mechanism, with the seconds dial at its ordinary place; but it must be objected to so much the more, as it not only burthens the train with moving an additional axis, but also with the friction which must be applied to this pinion by a small spring in order to prevent the shake of the toothing being indicated by the seconds hand.

153. It is possible to increase the above-mentioned angle by adopting essentially smaller train wheels. In the generally adopted type of the Swiss manufactures this angular distance is often increased up to 30° and even 35°, on account of the wheels being much smaller than they might have been with respect to the room afforded by the dimensions of the frame. A further increase might be obtainable by approaching the third wheel to the barrel so as to have it go under the toothed rim of the latter, at the proper distance for leaving it just free from the cylindrical part of the barrel. But with all these various efforts, and the constructive defects involved in them, it is not possible to establish sufficient room for the keyless parts.

154. For attaining this purpose, a step of greater boldness was necessary, which, notwithstanding its infringements against the principles of sound and correct construction, has been sanctioned by the trade and public, in the absence of a better expedient.

It consists in placing the third wheel pinion with its arbor quite close to the periphery of the barrel, and the necessary space for the wheel must be granted above the centre wheel. The drawbacks of this arrangement are evident. The additional height of frame required by the superposition of the wheels, and the close disposition of three large moving parts, one over the other, are certainly very grave objections; but a watch is, more than many other articles, dependent upon the reigning taste, to the tyranny of which its construction must be subjected, and this must account for the fact that almost all open-faced keyless movements are disposed in this way. (Fig. 39.)

It must be said in favor of this method, that all the parts of the keyless mechanism are the same, and may be indifferently used for open-

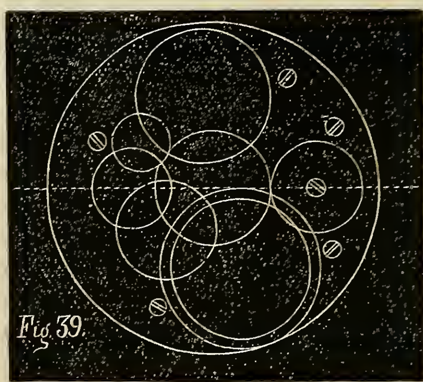


Fig. 39.

faced and hunting watches, and that all the parts of the train may be executed of the same regular dimensions as in a key-winding watch of the same size.

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Analytical Horology.

BY J. HEERMANN, LONDON, ENG.

DIVISION OF THE SUBJECT.

By reason of my long silence on the above subject, it is consistent with my promise of last communication to offer an apology. This I tender willingly, for it is due; but regretfully, because it is the result of an inclination to ill health, caused by years of close application. On this point I am sure that some of your horological readers can practically sympathize with me; hence I take it for granted that my apology is accepted, and so proceed to my subject.

In examining a horological instrument, as a watch or clock, we find that it presents four distinct features or properties, viz.: The source of power, its conversion into rotary velocity, this again into reciprocating intermittent motion, and last, the impulsive controlling force associated with this motion. Technically, we term these: 1st. The mainspring or the weight; 2d. The train; 3d. The escapement; and 4th. The balance and pendulum spring, or the pendulum acted on by the earth's gravitation.

These four sections are progressive in their comprehensive cardinalities, as well as in their importance relatively to the solution of the chief horological problem, "time," and hence

will receive our attention in the same order and ratio, of which first

THE MAINSPRING.

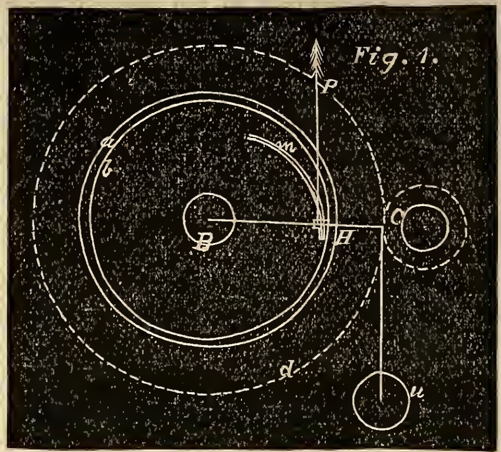
In speaking of the mainspring and its appliance, one feels called upon to apologize for introducing such an old and simple acquaintance. Yet for the very reason of its familiarity there are points in its range often unnoticed, and hence I hope I shall be pardoned for bringing a few briefly before the readers of the Journal.

In placing a spring into a barrel, say going barrel, the question arises, how to obtain a maximum resultant of force, with a minimum strength of spring. This question involves two distinct points, viz.: the physical properties of the spring, and the mode of its appliance to the barrel. The point as to the physical property belongs to the department of chemical metallurgy, and has to deal with the conditions that govern the elasticity of the spring—in tension and compression; for the strain comprises both, which involves again the qualities and properties of steel, the mode of manufacturing, the influence of the temperature, gases, etc. The second is a purely mechanical one. We observe three points, namely, the centre of motion or barrel arbor pivots, the appliance of spring or barrel hook, and contact of barrel with the object to which the power is to be communicated, which point of contact lies in the primitive or pitch circle of the barrel teeth. It is the relation that these points bear to each other that governs to some extent the effect of the mainspring on the centre pinion, and is synonymous with the principle of a lever of the third order.

Let B (Fig. 1) be the centre of a barrel, *a b* the barrel rim, *m* the mainspring, H the hook, and *d* the pitch circle of barrel teeth in contact with centre pinion at C, P the force and direction of spring, and W the effect on the centre pinion. We have here a simple lever, of which B C is the long and B H the short arm, the elasticity of the spring equal P, the effect on the pinion equal W, hence B C : B H : : P : W, and so the resultant of spring force, or

$$W = \frac{BH.\ P}{PC}$$

Therefore we see that economic appliance of mainspring force consists in very short teeth, a thin rim as near the teeth as possible, and a hook projecting no more than to give a firm hold to the spring.



I beg to notice the two modes of leading off the mainspring force: 1st, by teeth on the barrel or chain; and 2d, the one by a wheel mounted on the barrel arbor. The first one is now almost universally in use in non-fuzee watches, and possesses a property of compensating the varying spring force which I think may some day be used to advantage. This property can be explained by the principle of a simple lever with the power acting oblique. Fig. 1 will answer our purpose for explanation.

Suppose that the force of the mainspring were acting parallel to the line C B, then the whole force of the mainspring would be exerted in pressure on the barrel pivots, and none whatever to turn it about its centres, and so no motion could take place; or suppose it was acting in the direction from B to C, then we should have its whole force exerted in tension, and hence again no motion.

If, therefore, the force of the mainspring would be expended in pressure in acting in the direction from C to B, and in tension by acting in the direction from B to C, it follows that there must be an intermediate point where we have an equilibrium, at which point the greatest amount of force is exerted in turning the barrel about its centre, and the least in pressure or tension on its centres or pivots. This point must lie in a semicircle described from H, and at equal distances from its terminating points, which is a right angle to B C. As we get the greatest result for rotary motion when the direction of the spring force is at right angles to B C, and least when parallel, it equally fol-

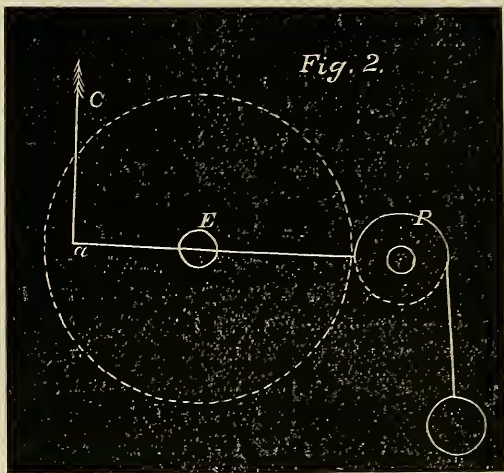
lows that the amount of spring force exerted in turning the barrel and in pressure on its centres, is proportional to the angle of direction with B C. The first is represented by sine P H B, and the latter by cosine P H B

The variation of the direction in which the spring acts constitutes, therefore, a compensating element, because this angle diminishes as the spring is wound, and so a proportionate part of the force is expended in pressure on the pivots.

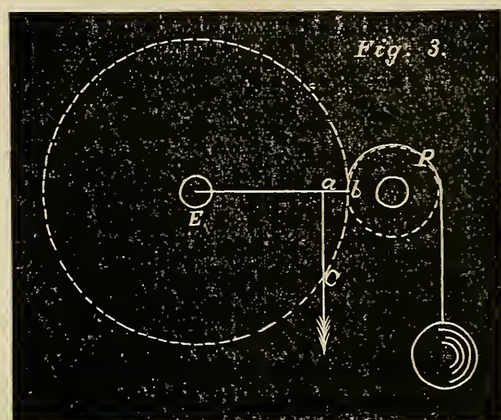
In barrel arrangements where the mainspring power is led off from the arbor, we have no mechanical variation. The mainspring is constantly acting on a fixed radius, and at right angles to it, which is the radius of the barrel arbor, and hence offers no compensation to the accumulating elastic force of the spring as coil after coil comes into play. This arrangement is certainly very old, but that is just the reason why it should be reinvented again.

The breaking strain of mainsprings is very varying, and the reason why is one of very wide range, as hinted at in the commencement of this article, but which is out of its present compass. Experience has found an approximate ratio between the thickness of the spring and the safe angle of inflection. This angle is determined by the ratio of the diameters of barrel arbor and barrel. By making the diameter of the arbor one-third of that of the barrel, we insure a curve to the spring corresponding to the same ratio of co-ordinates. To enter into the properties of these curves would be of little practical interest, and so I pass them by.

The inequality of mainspring force is a fact not to be disputed, nor is its effect in turning to be discussed at present, whether it should be controlled by the fuzee or pendulum spring. I shall, therefore, only now notice the mechanical contrivance of the fuzee in its immediate relation to the spring. Mere mentioning this piece of mechanism is sufficient, as being a contrivance for controlling the force of the spring, because it is not only described in horological, but in every other treatise on natural philosophy, so that I will not intrude on your valuable space with another. One point in connection therewith seems to create doubts in the minds of not only obscure watchmakers, but also prominent chronometer manufacturers—that is as to the modes of chain appliance: one being so that the chain leads off on the opposite side to the centre pinion, and the other so that the chain leads off between the fuzee and centre pinion. Both modes are illustrated in Figs. 2 and 3. F represents the fuzee and



great wheel, P centre pinion, C the chain. The difference is equal to the amount of pressure, and hence friction and wear exerted on the respective fulcrums of a lever of the first and third order.



Let a b represent a straight lever resting on the fulcrum F; let F $b = 10$ inches and F $a = 9$, and a weight suspended from $b = 9$, then we should require a force at a to keep this weight in equilibrio

$$= \frac{10 \times 9}{9} = 10$$

and the pressure on F would be $= 10 + 9 = 19$. If we substitute for the weight at b the pressure on the centre pinion, for the power at a the pull of the chain, and for the fulcrum the fuzee pivots, we have the conditions which prove

that the constant pressure on the fuzee pivots is equal to the pull of the chain plus the pressure on the centre pinion. Now let us examine the next figure.

Let F b (Fig. 2.)= a lever arm of 10, F a= 9, and F as fulcrum; a weight is attached to b, slung over the pinion C=9, and kept in equilibrio by a power acting at a; this power would have to be $= \frac{10\times9}{9} = 10$, but the pressure on fulcrum F is equal to $10-9=1$. We have therefore in both cases the same effect as to the weight raised, but in the first we have a pressure on the fulcrum of 19, and the latter 1. Or by substituting fuzee pivots we have on the first fuzee a pressure of 19 and on the last only 1.

Watchmakers applying their adjusting rod, and failing to see any difference, laugh at the idea. The real difference lies in the wear and tear of the fuzee pivots; extra pressure squeezes out the oil, the friction increases progressively with wear, and produces errors which will to a great extent be obliterated in Fig. 3. We will now very briefly notice the second source of power—

WEIGHTS.

I should feel tempted to pass over this item for its simplicity's sake, were it not for a recent incident that came to my notice, of a professed practical horologist, in close vicinity to the British Horological Institute, who put a large wheel to the drum of a clock in order to obtain more force, and then replanted the depth. The principle of the suspension of a weight from a string wound round a drum, fixed to a wheel acting into a pinion, is that of the wheel and axle. The weight is to the power communicated to the pinion as the radius of the wheel is to the radius of the drum; hence, if this said horologist had put a smaller instead of a larger wheel he would have obtained his object. Thus I shall conclude these few observations on the appliances of the source of power, and pass on, in my next, to the conversion of force into a rotary velocity, or the train.

——o——

☞ Mr. Grossmann, in a letter bearing date July 5th, says: "I start in an hour on a trip through Switzerland and France, on which I hope to gather valuable material for my next Essay."

Himmer's Electric Clock.

Since the advent of electro-magnetism as a probable motive power, there has been a constant endeavor among electricians to bring this agent into use for horological purposes. This universal desire, and the persistent attempts to effect this purpose, both by horologists who were not thorough electricians, and electricians who were not expert horologists, indicates that there certainly lies hid away within its unknown capabilities a power adequate to this end. The only conceded difficulty is in the adoption of the proper means. From the first experimenter to the last, each has overcome all the difficulties of his predecessors only to find new ones for his successors to overcome. Thus, as with every other art, failures have constantly been adding fresh greenness to its growth, till, like a coral reef, naked and barren at its first appearance above the surface of the sea, the death and decay of each successive growth of vegetation upon it furnishes new and richer ground from which spring new, more vigorous and valuable organisms, until the complete tropical island, crowned with beauty and utility, claims recognition among its geographical compeers. A similar culmination seems likely to await electrical horology. Each successive investigator has built upon the wreck of previous plans a better structure—avoiding, improving, discovering—till there seems every prospect of an achieved success for electrical clocks. In earlier efforts the electric current itself for want of uniformity in development, giving in consequence constantly varying power, was abandoned; but with the constant improvement in batteries, approximating to constancy of action, hope was again revived that the problem was not far from solution; still unexpected difficulties arose. By the use of the most constant batteries were developed troubles that had lain hidden in those constructions which worked successfully for a short time, and a new departure must again be taken.

Gravity escapements now offer the most tempting field for the application of electro-magnetic force to time-keepers. In these the motive power—that is, the power to keep the pendulum in motion—is as constant as any of those of which we at present know. And when it is remembered that a pendulum of 75

lbs. will give isochronous vibrations for many hours by its own momentum, without any assistance from any motive power, it will be seen how slight an additional impulse it will require to keep it in constant motion, and this minute force can be constantly and uniformly supplied by gravity. An almost infinitesimal weight thus applied to the pendulum at the end of each arc or vibration, will fully answer the purpose of keeping up the motion forever. As this small weight can be raised by an electro magnet, independent of any force upon the pendulum, and at the same moment the same force move a wheel or pinion equally independent of the pendulum, there appears no reason why the wheel or pinion should not register the vibrations of that pendulum with perfect accuracy. With such an apparatus a perfect pendulum will give a perfect record of its oscillations; and if such a pendulum, in its length and compensations beats exact seconds, such an electric arrangement as has been spoken of cannot do otherwise than record exact seconds of time, from which, by the simplest wheel-work, minutes and hours can be deduced. This is exactly what Himmer's Electric Clock purposes to do.

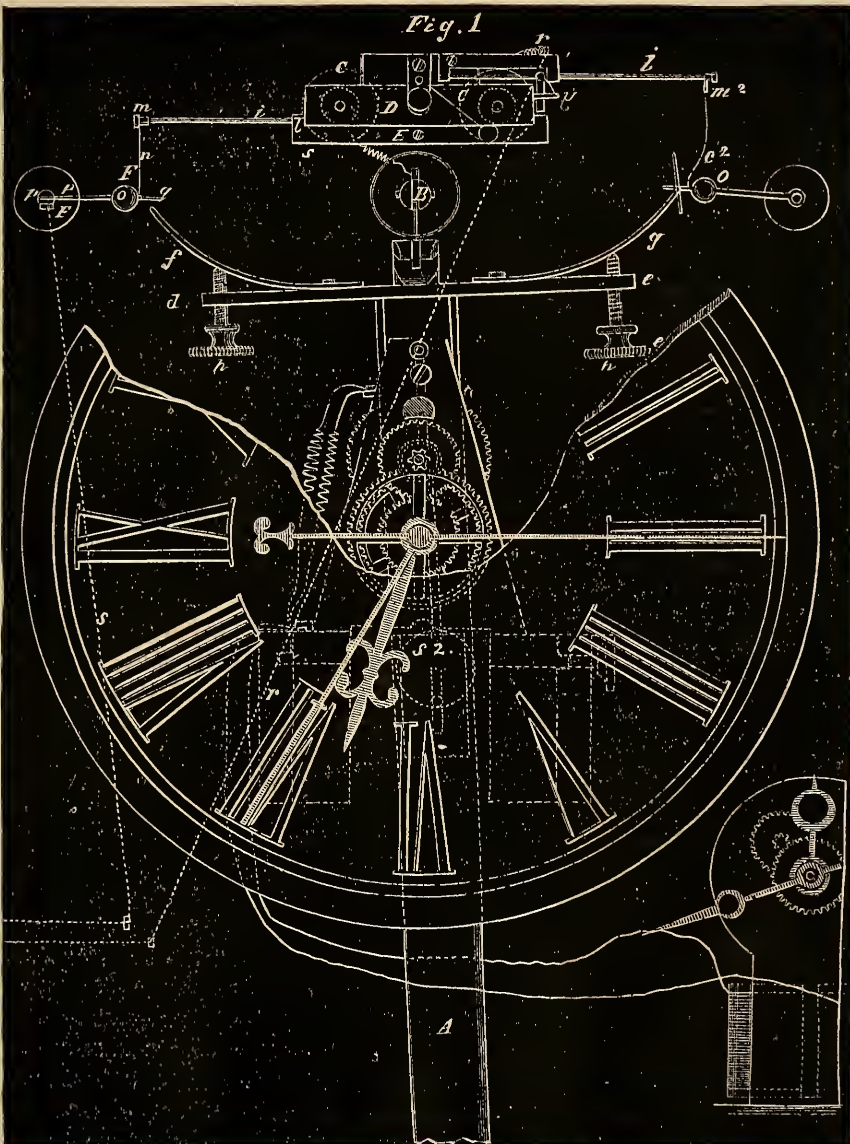
Every one knows the principles of the electro magnet; that when the electric current circulates through many convolutions of insulated wire around a piece of soft iron, it becomes powerfully magnetic; and the moment the current ceases no attractive power remains. This electro magnet, or rather two of them, not larger than, and much resembling, two spools of number 70 thread, are firmly secured to the back of a clock case or frame by means of a strong stud, and just above the pendulum A, which is also suspended from the stud B by its spring. At or near its upper end the pendulum is provided with two arms, *d* and *e*, projecting horizontally, or nearly so, in opposite directions; these arms carry upon their upper surfaces metallic springs, *f* and *g* respectively, which springs are bent upward more or less by the screws *h*. The armature D of the electro maget previously mentioned as being secured to the frame or support, is a flat iron plate vibrating on the arbors *i* and *j*, which project from its ends near the lower edge into ears *l*, of a plate E, that is connected with the electro magnet. One of the arbors, *i*, is firmly secured to the armature D, and at its end has an arm or crank *m*, the end of which is above the point of the spring F. By means of a hair or thin thread *n*, the crank *m* is connected with the weighted end or ball O, upon the spring F, which is fixed to the metallic pin or stud *p*, projecting from the frame or clock case, the metallic pin *q*, or axis of the weight projecting beyond it just above the spring *f*. The metallic conductors, *r s*, connect the battery, respectively, with the electro magnet C, and the pendulum spring or the stud which supports the pendulum. When the pin *q* is in contact with the platinum tip which forms the end of the spring *f*, the circuit is closed, and the current passes from *s* through the spring F and pin *q*, through the spring *f* and the pendulum spring, on through the electro magnets C, returning to the opposite battery pole by the wire *r*. While contact between *q* and *f* continues, the armature D is swung against the face of the magnets, and the arm m^2 raises the impulse weight O, through the agency of the pin *y* in the armature, and it remains raised until the retreat of the spring *f* from contact with *q* by the return of the pendulum breaks the circuit, and the armature falling away from the face of the magnets permits the weight O to rest upon the spring *g*, thus renewing the impulse for another vibration, first from one and then from the other, and as will be seen, each impulse receiving only the amount constantly given by the action of gravity upon the impulse weights.

By this means he has simply a pendulum vibrating seconds, or half seconds, as its length determines, and it is only necessary to put it in connection with a recording apparatus, which is a simple system of wheel-work affixed to the back of the dial and properly connected with the hands, to complete the clock. Each beat of the pendulum, or what is the same thing, each movement of the armature which the pendulum controls, moves the seconds hand one division of its circle.

A feeble circuit is sufficient to thus keep a pendulum in motion; in fact Mr. Himmer's greatest difficulty was to convince himself of the necessity of a feeble current, and small wire conductors. Again and again were they reduced in size and capacity, with constantly improved action. One of the results of this feeble current has been the elimination of one of the most troublesome difficulties attendant upon the old batteries, which was the accumulation of fungi

at the point where the circuit was broken, which in a very short time prevented the metallic contact necessary to perfect transmission of the current. With the present arrangement, and the slightly sliding motion of the parts as they come in contact, no difficulty of this sort has been experienced in two years of running.

By preference begot of experience and many experiments, he changes the reciprocating motion of the pendulum into the circular motion of the wheel-work by the peculiar arrangement of a friction roller upon a secondary pendulum, which actuates a click, that, by its own gravity, moves the train, thereby insuring a

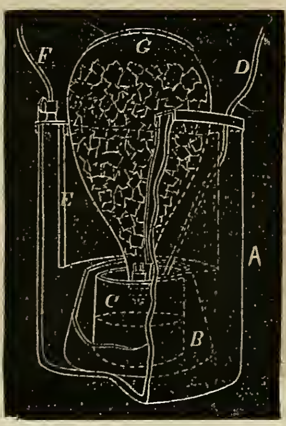


minimum of friction, because the train is really moved by the dropping of the click by its own weight, the office of the pendulum being only to raise the click while it is without connection with the gear. He also attaches to the arbor of the seconds hand of the clock a notched cam, or break circuit, whereby once during every revolution of the arbor, or at any interval desired, metallic connection is established and broken in a circuit that leads to a second or secondary clock-work, actuating the same in unison with the primary one. The minutiæ of construction in these electric clocks, the various ingenious devices for the necessary adjust-

ments, show at once the inventor to be a mechanic inferior to none in his art, and who seems to have shown in its execution all the skill which he possesses as a watchmaker.

In the search for batteries adapted to his clock none were found in all respects suitable; some were attended by constant trouble to keep them in working order, and the inequality of action in the so-called constant batteries would not do for his purpose; others were quite useless, owing to the corrosive and offensive vapors evolved when in action, thus necessitating the placing of them in remote and inconvenient localities. These difficulties forced upon him the invention of a battery as well as a clock, and he finally succeeded in producing a truly constant battery, which, being self-feeding, could be left alone for one, two, or three years without being looked after. Being small, odorless, and perfectly cleanly, it is admirably adapted, not only to his electric clock, but for medical purposes, small magneto-electric engines for sewing machines, private telegraphs, hotels, burglar or safe alarms, etc. They are especially adapted to the wants of the watchmaker and jeweller for electroplating, because they are inoffensive to sight and smell, and, there being no corrosive gases evolved, are harmless among the shop tools.

This necessary research has, therefore, brought into notice a most convenient, useful, and elegant battery, consisting of an outer



glass jar A, in which is suspended, by an angular flange, the zinc cylinder E, to which is fixed the coupling screw F; upon the bottom of the jar is placed the conical glass B, and standing in it is the copper cylinder C, to which the circuit wire D is attached. The inverted balloon-shaped flask G is closed by a stopper through which two short glass tubes extend their small ends upward into the flask. In use the jar should be nearly filled with water, in which one pound of sulphate of magnesia is dissolved by being stirred with some non-metallic rod. The interior diameter of the zinc cylinder should be such that the bulb of the flask will keep it from descending to the bottom of the jar. The flask must be filled with three pounds of broken sulphate of copper, and the interstices filled with water, the stopper secured in, and the flask inverted as shown in the drawing. The action of the battery depends upon the height to which the solution rises about the copper cylinder, as it flows out of the flask; consequently the farther the tubes are drawn out the weaker will be the action of the battery. Prof. Van der Weyde says that eight of these cells, set up in a closet in his library room, answer all purposes of chemical operations, working the small Ruhmakorf coils, small electro-magnetic machines, etc.

Mr. Autenrieth, who has become associated with Mr. Himmer in the manufacture of electric clocks, has for many years been largely engaged in the manufacture of first-class regulator cases for the wholesale trade. He also has made a specialty of the three-side plate-glass Vienna and Parisian half seconds cases, and they propose to fit them up with electric clocks, the battery concealed above the clock by the ornamental scroll-work upon the top of the case. For regulators the battery is concealed within the pannel-work of the base, the wires conducted within and entirely out of sight.

If persevering industry and skilful labor can command success Messrs. Autenrieth & Himmer will succeed in making this improved electric clock a permanency among our American time-keeping productions. Their peculiar adaptability to localities where numerous coincident time-keepers are required is an especial feature of their merits. Large factories can have, in every department, a dial which will register the pulsations of a primary clock in the office, thus avoiding the endless controversies between men and the time-keeper as to hours. Cities and towns can, at comparatively trifling cost, establish public dials, at convenient localities, as regulators of public and private

labor, that will insure a much to be desired uniformity.

The Himmer Electric Clock is manufactured by Messrs. Autenrieth & Himmer, Long Island City; office, 371 Pearl street, New York city.

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Watch Repairing.—No. 2.

BY JAMES FRICKER, AMERICUS, GA.

[The reader will please erase the word "*not*" where it occurs in the 4th line from the bottom of first column on page 9 of the last number of this JOURNAL; it was a typographical error, and materially alters the sense of what I intended to say.]

We will now take up the subject where we left it in the last number, the watch all to pieces, and ready for any repairs needed. We will suppose our present difficulty lies in the barrel; the mainspring broken, the barrel spread, and the holes worn too wide. Now for the remedy. In the first place, with our barrel-closer or contractor, we will contract or close the barrel to its original size by placing it in one of the holes that is slightly smaller than the barrel, with the upper or open side of the barrel down, placing the disk over it, and tapping lightly the bar that is screwed into it until the barrel is reduced to the proper size. Next, bush the holes, having first reamed them out; or what is still better, cement the barrel up on a chuck in your foot lathe, the outside against the face of the chuck; then bore out the hole and turn down the projection a little for a shoulder; then make a bush with a square shoulder, and fit it from the inside of the barrel, and the same with the lid. After riveting in these bushes put the barrel back on the chuck again, using a brass chuck, with a hole in the centre as large as the arbor pivots; true up the barrel by its periphery, then drill a hole in the centre, and bore out the hole nearly large enough to take the pivot, and turn down the shoulder to the same thickness as the old one. If the barrel does not run true, true it up with a graver, and if it will bear it, true out the groove for the lid, leaving it slightly undercut; take the barrel off, and put up the lid, and true it up by the outside same as with the barrel; centre and drill a hole, and bore it out slightly smaller than the pivot that is to go into it; turn the shoulder back to correspond with the old one, then fit the lid to the barrel if it is too large. If too small, it should have been spread a little with a smooth-faced hammer before putting it up in the lathe. Now take it off, and with a round broach fit the arbor, always wetting the round broach when using it, as that will prevent its tearing up the brass. To avoid getting the barrel either too high or too low, it is well to bush the barrel and fit the arbor before bushing the lid, so that you may be certain to get the end-shake right, and have the barrel the same height as before; then bush the lid and fit it to the barrel, and fit the arbor and get the end-shake again by turning off the shoulder of the lid. Now see if not only the end-shake is right, but that the barrel runs true on its arbor; if not, correct it as directed in previous article.

If a proper degree of care has been exercised, the barrel will now be ready for the mainspring; but first let us suppose the old barrel was in such a bad condition, so sprung or cracked, that it could not be remedied as above directed, in which case a new one must be supplied. If you can get one from the material dealer in time, of the proper size, it will save some work, as it is not an easy matter to fit a new one. Proceed the same as above described for an old one, after it is bushed. Always true it it up by the outside, then you can get your hole concentric with the circumference of the barrel. Every one should have a Swiss gauge to get measurements by, as it will save much trouble and time. First get the outside the proper size, then bore out the hole nearly large enough for the pivot, then true up the inside with a graver or cutter; turn down the groove for the lid until it measures the same distance from the bottom of the outside of the barrel as the old one, premising that the old one was correct; turn down the shoulder to the same thickness as the old one. Before taking the barrel off the chuck, satisfy yourself that it is of the proper size and thickness, and that the shoulder for the lid is correct, and the end not too thick; then take it off and try in the arbor, first having opened the hole with the round broach; try the height by putting it between the plates with the arbor in it; next fit the lid, which may be too thick and require to be turned, filed, or stoned down a little. Now drill a hole for the

hook, and carefully file out a rectangular hole, which should not be drilled directly towards the centre of the barrel, bnt at about an angle of 45° from the radius, so as to hold the hook when the mainspring is in; after which polish up the barrel and lid with oil-stone powder and oil, next with tripoli, and then with rouge, or Vienna lime. If you cannot obtain a barrel in time, and have to make one, select a piece of brass somewhat thicker than is required, and hammer it well so as to harden it, and close up the fibres of the metal; with a pair of dividers strike a circle the size of the intended barrel, after having made a good centre; then cut away the bulk of superfluous metal from the outside of the circle with a saw and file, then cement it on to a brass plate that is perfectly true, and when cold put it up in the universal lathe, and if you have a hole in the centre of your plate large enough to let your pump centre come through, and your blank, with its centre down, is immediately over that hole, you can easily put it up true; make a new centre, and inscribe a circle on the now outside for a guide. Now drill a hole clear through the blank, a little smaller than the pivot that is to go into it, then turn out for the inside of the barrel, allowing for thickness of the rim from the circle. The Swiss gauge will come into use all this time in getting the thickness. Allow for your shoulder, and turn out the groove for the lid, and make the barrel the proper height; then turn up the outside, being careful not to go down to the brass plate until you have finished it, or you will jar the barrel off. In cementing the blank, or in fact anything, on to a plate or chuck, always rub the article about, using considerable pressure, so as to get as much of the shellac out from under it as possible before it cools. Now if you have previously faced off the other side of the barrel, you are ready to drill for the mainspring hook, and then polish it up, and, if you are prepared to do so, gild it. It frequently happens that you can use the old lid when putting in a new barrel, which will save some work.

It is impossible to lay down any absolute rule as to the strength and length that a spring should be in any one of the various watches that come to us for repairs unless we know the character and quality of the train and escapement, weight of balance, etc. Take two watches of the same caliper and same train as far as the number of teeth in the wheels and pinions are concerned, but of far different finish, and the shape of the teeth of one as near perfect as possible, and of the other as imperfect as they could well be made. Now, one of these watches will go with a weak spring, whereas the other requires a very strong one, especially if the escapement is bad, which is usually the case when the train is not properly constructed; but to be safe, always use as weak a spring as possible, that will be certain to drive the watch, and give the balance a good motion. Another important fact connected with mainsprings, and that every one should know, is this; a wide thin spring gives better and more constant results, besides being less liable to break, than a narrow thick one. Always use as wide a spring as the barrel will take, and as thin as will drive the particular watch you may have in hand; furthermore, there should always be one full turn more of the spring in the barrel than is actually used, and in very fine watches we frequently see two, especially in the Swiss and American. If the old spring was right, select one of the same width and strength. A pivot gauge should always be used to get the strength, and not depend on springing it with your fingers to test its strength. By careful observation you will soon learn to select a spring with but little trouble. You may have to change a few springs on account of their strength after putting them in, but if you do that will teach you more than twenty pages of printed directions. After having selected the spring that you intend to put in, break it off full long, try it in, and if the open space between the spring and the arbor is equal the spring is of the right length, provided the strength is correct; take it out and heat it with the alcohol lamp, from the end to half an inch back, but do not heat it red hot, but remove it from the flame when it is black; punch a round hole one-fourth of an inch from the end, then put the spring in the bench vice, so that one-third of the end of the spring projects above the jaws of the vice, and opposite where the hole is, letting it come even with the top of the vice; file the exposed part away, turn it over and serve the other edge the same way, which will leave the spring one-third its original width at the end, and the full width opposite the holes; then thin the end down with a

file to one-half its original thickness, but do not file the inside of the spring any; countersink the hole slightly, when it will be ready for the hook.

If the hole in the barrel is rectangular, select a piece of flat steel wire as near the size as possible (if a round hole, take round wire); file it down so as to fit the hole perfectly free, then put it in the pin vice, letting it project about one-sixteenth of an inch, and instead of putting it straight through the jaws of the vice as you do pin wire to make pins, deflect it to an angle of about 45°; now hold the vice the same as you would to make a pin, and file up a tit on the end of the steel wire, making a square shoulder with the jaws of the pin vice for your guide; examine it with a glass and see if you have got a good shoulder. Where the tit meets the hook it should be towards the front of the hook, so that the bulk of the metal will project back of the tit, which renders it more secure and less liable to pull out. Now, when you have got the tit well fitted into the spring and a good shoulder to it, take it out of the pin vice and fasten it in the bench vice so that the shoulder projects slightly above the jaws; put the spring on and rivet it fast; cut off the wire, leaving enough attached to the spring to make the hook; see if the hook fits the hole in the barrel; put it through from the outside, and mark on the inside where it comes through; then file down to that mark, making the end of the hook of the same curvature as the barrel; stone it to get the file marks out, then burnish it; clean it and the barrel and put it in with the winder. If the hook projects at all take it out and file away as much as will be necessary to bring it down flush. Never file it when it is in the barrel, as that will disfigure the barrel. Clean and put it in again, oil it, put in the arbor, put on the lid and oil the arbor pivots, and with a pair of hand tongs wind the spring up full to see if it will stand, which also distributes the oil that is on the spring. The spring and barrel are now ready for the watch.

A very useful little tool for squaring up the shoulder of a main-spring hook is easily made by drilling a hole the right size into the end of a piece of steel wire which should be fitted into one of your chucks. After drilling the hole and facing it up, take a very thin saw and saw a slot right down the centre of the hole a short distance, then carefully file it up so as to leave two cutting edges, removing the metal in front of each cutting edge, which will give it the appearance of a carpenter's bit that has the point broken off, and a hole drilled where the point had been. When you have filed up the tit on the hook, put the cutter in the lathe and place the tit in the hole and press the shoulder up against the face of the cutter, and you can make a perfectly square shoulder in a few seconds.

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"Clyde" on the Friction Question.

In common with many readers of the Journal, I feel deeply interested in the controversy on friction, and especially in the full development of any new experiment or new fact that can be brought forward to support either side of the question. There is one experiment, however, which has been made by B. F. H., with the mandrel of a Swiss lathe, which he describes in the May number, that I consider has a tendency to mislead those who may be studying the question of friction on long and short bearings, as it evidently does mislead the author himself; and I would respectfully beg leave to make a few remarks in opposition to the views held by B. F. H. on the friction question, and to analyze his experiment.

In the first place, I assert that *large flat bearing surfaces have no more friction than smaller surfaces, if the character and quality of the surfaces are in all instances the same, and when the force with which the surfaces are pressed against each other is also the same.* On the surfaces of the smoothest of bodies there exist asperities or irregularities which lock into each other when one body lies upon the other in a state of rest, and before motion can be produced these asperities must either be broken off and worse ones formed, or one body must be separated a sufficient distance from the other to allow the asperities or irregularities to pass each other; and the greater the pressure that is upon the bodies the greater the amount of force that will be required to support them; still, with the same weight or pressure, a surface in contact, say one foot broad, will be raised and motion produced just as easily as if the surface was only one inch broad, providing the surfaces be *equally regular and flat.* If the surfaces are

irregular, then a greater amount of force will be required to move one over the other, because they must be separated a greater distance to allow the irregularities on the surface to clear each other. Bodies with smooth surfaces move easier than those having rough or irregular ones, simply because they have to be separated a less distance in one case than in the other when motion is produced.

If we imagine two files, for example, to be flat and straight, and the teeth cut in the sides and edges to be of the same degree of fineness, one file will be moved horizontally over the other one just as easily when the broad sides rest on each other as when only the narrow edge of one rests on the broad side of the other, because in both instances it takes the same amount of force to separate the surfaces far enough to allow the points of the teeth to pass each other. If the files, however, be irregular on their surface, although the teeth be of the same degree of fineness, it is plain that, before motion can be produced, they will require to be separated a greater distance, and far enough to allow the largest of the irregularities to pass each other; consequently it will take more force to move them, because one file has to be separated a greater distance from the other to allow the points of the teeth on the highest irregularities to pass the others.

In the example of a bearing surface one foot square, and another bearing surface only one inch square, and when the surfaces are equally smooth and flat, the theory is that the pressure upon the body is equally distributed among the particles of matter that compose the surface, and each particle on the surface that is one foot square has a proportionably less amount of weight to bear than each particle on the surface that is only one inch. If the pressure be very great there will not be enough of particles to sustain it, and some of the particles will be broken off and other irregularities formed that will alter the character of the surface altogether. From this it is only plain reasoning to assume that the extent of a surface should be in proportion to the amount of pressure that is upon it, and the material from which it is made, because if the surfaces are narrower than will support the amount of pressure that is upon them, ruts and other irregularities will soon be formed; and if the surfaces be very broad the difficulty of making them flat will increase with their extent.

It appears to me that Mr. Gribi, in both of his brick experiments, has given ample evidence that with flat surfaces friction is independent of the extent of the surfaces in contact; but if his experiments in this direction are not accepted as conclusive by every reader, I would state that the very highest scientific authorities of the day corroborate the accuracy of the results obtained by him, as well as the soundness of his theory, which is proved by models for illustrating mechanical philosophy. Those readers who live in the neighborhood of New York city will probably most readily get access to mechanical models necessary to prove the principles involved in this question by applying at the class-rooms of the Cooper Institute, as I know that they have models there for this purpose. Parker's Philosophy, and other elementary works of the same description, may not advance these principles of friction, but they do not deny them. I have studied a great many encyclopædias and standard works on mechanics, and all of them support the doctrine that friction is independent of the extent of the surfaces in contact. Even the ordinary engineers' hand-books which contain tables for the use of practical engineers in constructing machines, have got tables showing the coefficient of friction, and if it be necessary to give any stronger proof than I have done I would simply allude to the celebrated experiments of M. Morin. About forty years ago experiments were instituted at the fortress and military arsenal of Metz, by the order and at the expense of the French Government of that day, in order to prove certain theories concerning friction, where it was demonstrated, by a series of practical tests which lasted over a period of three years, that while different kinds of substances had a different amount of friction, narrow and broad surfaces of the same quality, and made from the same material, had exactly the same amount of friction when they were equally clean and dry, and when the pressure was not so great as to bruise the surfaces. The accuracy of these experiments have been verified again and again by experimenters of a more recent date, and he would be a bold man, indeed, that had a knowledge of these facts and attempted to contradict this theory.

In the second place, I would remark *that the friction produced by the circular motion of a round surface working against a hollow one, such as a pivot working upon its bearing, is an example of sliding friction of the same nature as one flat surface sliding over another.* When one or two pivots lie in their bearings in a state of rest, the asperities on the surfaces of each interlock with the asperities on the surfaces of the bearings, and before motion can be produced these asperities must either be broken off, or the pivot must be separated a sufficient distance from the bearing to allow the points of the asperities on each to pass the other; and whether the pivots be long or short they will be separated with equal facility if they are true and straight, and if the pressure that is upon them be equal under all circumstances. However, in the case of the round pivot and its hollow bearing, it must be observed that if their surfaces be not regularly true and straight, the resistance to motion will be greater than in the case of the flat surfaces. In the case of the two flat surfaces there is a chance for one body, when it is being moved over the other, to move a little to one side or the other, and in that way slight irregularities may sometimes clear each other without the two bodies being separated so much as otherwise it would be necessary to do; but in the case of round pivots in hollow bearings there is not that equal state of freedom for the moving body to move to one side, and consequently, as has been observed already, any defects or irregularities in the surface of the pivots or their bearings, however small, will cause greater resistance to motion than defects of equal magnitude existing on two flat surfaces.

In the experiment described by B. F. H., on page 261 of third volume, the steel mandrel of a Swiss lathe, 0.35 of an inch in diameter, with a bearing surface 2⅝ inches long, is used to show the supposed effects of friction on long and short circular bearings. It is stated that "the fitting is perfect—in fact no work could be better." Now, we all know what the mandrels or centres of Swiss lathes are. The most of them are very nice, and sufficiently accurate for the purpose for which they are used; but, with all due deference, I deny that any of them are sufficiently true and regularly straight to be used for an experiment of this kind. If we were to place one of these mandrels or centres in a fine lathe in such a manner as to test the equality of the roundness and straightness of its form, for instance by a lever attached to the slide-rest with its shortest end pressing against the mandrel or centre that is being tested, and the other end considerably prolonged so as to magnify any motion in the short end that may be produced by the work that is under trial revolving against it, we will find that the very best of Swiss lathe centres or mandrels are not regularly true and straight for 2⅝ inches in their length, although the most of them are near enough for the purpose they are used for; and I am willing to admit that in some instances they are used for very particular purposes, although of an entirely different nature from the one in question.

In trying this experiment I wonder if B. F. H. placed the pulley on the end of the spindle outside the bearings, or if he cut away a place in the tail-stock of the lathe and placed the pulley in the centre. The experiment could be of no value unless the pressure was always in the direction of the centre of motion of the revolving body. The pulley would be more convenient placed outside; but its action would cause the pressure at one end of the spindle to be downward, and at the other end to be upward, and thereby materially interfere with the accuracy of the experiment. A strange part of the experiment, and which I am at a loss to find a reason for, is in making one of the bearings of Babbit metal. To give such an experiment justice, all the bearings should not only be made from the same kind of metal, but if possible they should be cut out of the same piece of metal, in order to insure the same quality of surfaces on the holes. Perhaps B. F. H. felt generous and was giving his opponents the benefit of the advantage of this anti-friction metal, which is so beneficial in bearings where there is a high rate of speed; but the velocity of his spindle was slow, and the motion was but of short duration, and it is doubtful whether his opponents did receive any advantage by his using that metal. He also leads us to suppose that the entire surface of the holes touched the entire surface of the mandrel that was not exposed to view. Babbit metal, like lead, is one of the most difficult that he could select to make a hole of the

diameter, length and quality of surface desired. I do not doubt but what all the holes fitted the mandrel in such a manner that the mandrel had no apparent shake, and I am also willing to admit that none of them did bind perceptibly; but I can scarcely believe that each particle of metal that composed the surfaces of the holes touched equally all the particles of steel on the circumference of the spindle, or that they touched each other with the same force or pressure in every position in which the mandrel was turned.

As regards the fitting of the mandrel to the tail-stock of the lathe, I would remark that Swiss lathe makers cannot afford to spend the time necessary to make a hole with a surface of such a character; besides, it is entirely unnecessary for the purposes of a lathe, for if the mandrel or centre works into the tail-stock freely, and without shake, it is all that is required for that purpose. With some knowledge of the difficulty of making a hole of the character we are discussing, I venture to assert that there are but few watchmakers or fine clockmakers in the country who have either the facilities or the experience for making such a hole. There are thousands that could make a hole that one could see through; and there are many who might fit up some temporary arrangement and make a tolerably true hole and grind it to fit a mandrel if the mandrel was a little tapering; but to make a hole to fit a straight mandrel with the desired accuracy is altogether a different kind of a task. To make a straight and true mandrel or pivot, .35 of an inch in diameter, and $2\frac{5}{8}$ inches long, and to fit a hole to it so perfectly that all the particles on the surface of the one will touch lightly and equally on all the particles which compose the surface of the other, and which would be necessary in order to give justice to an experiment of that nature, on account of the top section of one of the bearings being nearly cut away, is indeed a very formidable undertaking to execute, and would consume far more time than the majority of people would be willing to spend for such a purpose. I have no hesitation in giving it as my opinion, and I judge from the manner in which the experiment was conducted, that the surfaces of the holes and mandrel were not regularly and equally of the same quality, and that they did not fit each other with the necessary uniformity; for if they had, and if the pulley was in the centre of the spindle, the experiment would have been likely to give results favorable to the theory that friction is independent of the extent of the bearing surfaces. Perhaps it may be well to mention, so as to prevent any misapprehension in the minds of any of the readers, that in an experiment of this kind it is not requisite that the bearing surfaces should be of any special degree of fineness, so long as they are of equal fineness and truth, and the spindle fits into all the bearings with precisely the same amount of freedom.

In conclusion, I would ask why make the bearings so long, and why make them to touch the spindle on its entire circumference? It only makes the experiment the more difficult to execute and get reliable results from it, and although the circular bearing surfaces were ever so regularly and perfectly formed, a small particle of dust getting in between them would bind them, or even a change in the temperature would show different results at different times. No pivot holes ever touch the pivot all around at the same time. In ordinarily close-fitted holes probably not more than one-third of the circumference of the hole and its pivot touch each other at the same time, and with wider fitted holes it is, of course, less. An experiment with a wheel having pivots of a size and length in reasonable proportion to the weight or pressure that they have to bear, and having a little side shake, would be much easier executed, and would also be more like that kind of friction we have to encounter on the pivots of timekeepers.

Mr. Kessels' Remarks on the Temperature of Rooms.

We have received from Mr. Grossmann the memoir of Mr. Kessels, of Altona, which he referred to at page 185, third volume of the Journal, in his reply to "Clyde" on the pendulum controversy. We have made a translation of the memoir, and present to our readers that portion of it which shows the difference Mr. Kessels found to exist in the temperature of the atmosphere at each end of a pendulum.

"The Mercurial Pendulum stands first among the varied and important inventions with which Horology was enriched by the

celebrated Graham, who was the first to propose, in 1715, the use of two metals of different expansibility for the compensation of the pendulum. This pendulum has been almost the only one used in England since the commencement of this century, and has many advantages. 1st. The great simplicity of its construction; 2d. Because the height of the column of mercury has been exactly determined by mathematical calculation; 3d. Because when furnished with an index it is as sure in its indications as a thermometer, particularly if placed in an observatory where there is no sudden change of temperature. The pendulum of my regulator is a gridiron of a peculiar construction. I assured myself, by repeated proofs, that the compensation was too strong, and that it was necessary to pierce new holes to change the relative length of the brass and steel rods. I removed it for a while, replacing it by a mercurial pendulum.

"The entire year of 1847 the rate of the clock was very regular, and from September 23d to December 13th it was as follows:

From	September	23	to September	31,	8	days	..0.02.
"	"	31	" October	12,	12	"	..0".04.
"	October	12	" November	8,	27	"	+0.01.
"	November	8	" December	12,	35	"	+0.01.
"	December	13	" January	8,	26	"	.. 0.47.

"As it is only since December 13 that cold weather has commenced and considerable heat has been turned on, I think, consequently, that its change of rate results only from the increased temperature which lengthens the rod, since the extent of the vibrations remain the same. I then placed two thermometers, agreeing perfectly, in the case, one near the point of suspension, and the other near the middle of the ball, and, by repeated experiments, have found a difference between these two thermometers of 3° to 4° Reaumur, the lower one indicating 3° to 4° less than the higher one. I hung these thermometers in my room, one at 1 foot 10 inches above the floor, and the other 3 feet higher. I then found a difference of 3° between them. Thence I think the difference of 1° more than was found inside the case proceeds from the heat striking the upper part of the case; and the wood, though a bad conductor, gradually increases in temperature, while, on the contrary, the cold rises from the floor and acts on the lower part of the case. I placed the same thermometers at the same height and distance in an unused room, which was never warmed, and found no difference between them; and it would be the same, doubtless, in an observatory. From the preceding it is very evident that its decrease of rate since December 13, proceeded from the rod of the pendulum experiencing 3° to 4° greater heat than the mercury, thus showing the impossibility of making a mercurial pendulum perfectly compensating in an artificially heated room. I should remark here that during the entire winter the temperature in the case is never more than 16°, and during the summer, when the rate of the clock was so regular, the thermometer in the case has often indicated 18° to 20°. The gridiron pendulum in this case would seem preferable, for if the temperature is higher at the top than at the lower part, the nine compensating rods are equally affected by it. But in its compensating action it is not nearly as regular, and it is very difficult to regulate it, for in any room (artificially heated) it is impossible to obtain a uniform temperature throughout its entire length, and without that all proofs are necessarily inexact.

"True, the length of the rods of steel and brass for the gridiron pendulum has been found by nice exact mathematical calculation, as well as the height of the column of mercury for the mercurial pendulum; but the brass and yellow copper being a most variable composition, it is impossible to construct two gridiron pendulums equally compensating."

Mr. Kessels, of Altona, enjoys a high reputation among astronomers on the Continent of Europe as a maker of fine clocks, and we consider any experiments that may have been made by him are worthy of our earnest consideration. In connection with this subject we direct the attention of our readers to the remarks of "Clyde" on this question in our last number, and also to the experiments proposed by him with a view to determine the *average* difference that exists in the temperature of rooms or apartments where standard clocks are usually situated. For the guidance of those who desire to make the experiment it is proposed that the thermometers be suspended *inside* of the case when it is practicable to do so, but when this cannot be done thermometers suspended on the outside will show the difference that exists there. It is

also proposed that the thermometers be compared three times a day—as early in the morning as possible—at noon, and as late at night as may be convenient.

The reader will bear in mind that 3° Reaumur is equal to about 7° Fahr., and 4° Reaumur equal to $10\frac{1}{2}$° Fahr.

Horological Instruments at Greenwich Observatory.

The Astronomer Royal's Report on the Greenwich Observatory, for the year ending 1872, June 1st, gives the following particulars respecting the horological instruments in use:

In 1871, December 1, the watchman's clock, upon which are registered the visits of the night-watchman, was moved from the astronomical observatory to the magnetic offices. As the watchman, while not on beat, occupies the gate porter's cabin, this arrangement insures the visits of the watchman to every part of our now widely-extended premises. The clock-registers are read and entered in a book every morning.

The mechanical arrangements, as regards transits and time arrangements, have been completely modified by the introduction of the normal sidereal clock. This clock is planted in the magnetic basement, as the locality in which the temperature is most uniform. Its escapement is one which I suggested many years ago in the Cambridge Transactions; a detached escapement, very closely analogous to the ordinary chronometer escapement, the pendulum receiving an impulse only at alternate vibrations. The pendulum compensation is of steel and zinc. For adjustment of rate, I have placed a sliding weight on the crutch-rod, where it can be moved by a nut at the level of the crutch-axis, without disturbing the pendulum. I have also arranged upon the crutch-axis a peculiar apparatus (not yet tried) for adjusting the final rate of correction for temperature. At the middle of every vibration the pin on the pendulum presses two light springs into contact which complete a galvanic circuit; and a pin on the 60-seconds wheel interrupts the circuit once in each minute. The current thus put in motion, acting by relay, makes the seconds-punctures upon the chronograph-barrel, drives or regulates various sympathetic clocks, and in fact does all which the current from the transit clock Hardy formerly did; but it does it a great deal better. The steadiness of rate is very far superior to any that we have previously attained. One evidence of this is the regularity with which it indicates the barometric inequality.

As the eye and ear observations (of circumpolar stars, etc.) are recorded by means of the transit clock in the transit circle-room, it is necessary to possess some means of comparing the normal sidereal clock with the transit clock.

This is done by the contact springs in the transit clock, which are placed in connection with the wires by which, in ordinary transits, the finger-touch causes a puncture on the chronograph barrel; the normal sidereal clock at the same time making its puncture by its own wires.

This clock was constructed under my direction by Messrs. E. Dent & Co., and may be regarded, I think, as an excellent specimen of horology. It was brought into use in 1871, August 21.

Other clocks have had small repairs and cleanings, requiring no special notice.

The chronograph is in good order. A small alteration has been made in its break-contact apparatus. Since 1871, October, glycerine has been used instead of water for producing the small resistances to the pendulum movement and to the movement of the friction regulator, which are required in Siemens' chronometric governor; and it possesses this advantage, that it does not cause rust in the steel-work. A trifling inconvenience is produced by the absorptive power of the glycerine, which sometimes fills the cistern more than is desired.

At the present time the number of chronometers lodged in the chronometer-room is 177. Of these, 137 are the property of the Government, namely, 93 box-chronometers, 26 pocket-chronometers, and 18 deck-watches; 40 are the property of chronometer makers, undergoing the annual competitive trial. All chronometers are compared with a mean solar clock, which is sympathetic with the normal mean solar clock; some (including among others the chronometers on competitive trial) are compared every day, some only once in a week; all are rated for a limited time in different magnetic positions, and all occasionally in high temperatures.

Six of our chronometers were lent to the expedition for observing the eclipse of 1871; all are now returned.

The average excellence of the first six of the chronometers whose competitive trial terminated in August, 1871, is slightly superior to that for 1870, and comparable to that for 1869.

Some time since, an accident happened to a chronometer from the weakness of the bottom of its wooden case. To prevent a repetition of this, I have had that part strengthened in all instances where it appeared advisable.

At the request of M. Quetelet, a chronometer belonging to M. Briart has been rated for several weeks. A mean-time clock for hourly galvanic signals is now being tested preparatory to its being sent out to the Cape of Good Hope Observatory.

On 10 days, the violence of the wind has prevented the raising of the time-signal-ball; but no failure has occurred from other causes.

The clock used at Deal in case of failure of the Greenwich time signal was cleaned in November last, and has performed well since. The ball was dropped by the current on 90.7 per cent. of days since the last report; on 4.9 per cent. the assistance of the attendant's hand was required; on one day the ball was not raised on account of high wind; on two occasions it was dropped a few seconds before one hour accidentally (by signals from telegraph clerks), which is notified to the public by the exhibition of a black flag; and on 3.6 per cent. communication was interrupted. In the two latter cases the ball is dropped by hand at two hours instead of one hour.

Some further correspondence with reference to the proposed establishment of a system of hourly time signals at the Start Point has resulted in a determination on the part of both the Admiralty and the Board of Trade to adhere to their former decision adverse to the proposal.

I am informed by the Engineer of the Post Office Telegraph Department that the distribution of time-signals is becoming more extensive; and a greater battery-power has become necessary at the Royal Observatory for working the additional relays at Telegraph street.

The automatic report of the clock of the Westminster Palace shows that 60 per cent. of its errors are below one second, 91 per cent. under two seconds, and 98 per cent. under three seconds.

In preparation for the transit of Venus in 1874, the first-class clocks are complete, two of the Observatory clocks being fitted with zinc and steel pendulums; nine second-class clocks are in hand, and the Observatory can furnish one. A special frame has been mounted in the lower south-east room for attachment of the numerous clocks during their rating.

I was made aware of the assent of the Government to the wish of the Board of Visitors, as expressed at their last meeting, that provision should be made for the application of photography to the observation of the transit of Venus. It is unnecessary for me to remark that our hope of success is founded entirely on our confidence in Mr. De La Rue. Under his direction, Mr. Dallmeyer has advanced far in the preparation of five photoheliographs, improved upon that which has acquired so much reputation at Kew; and I am awaiting Mr. De La Rue's final instructions for preparation of the huts. The subject is recognized by many astronomers as not wholly free from difficulties, but it is generally believed that these difficulties may be overcome, and Mr. De La Rue is giving careful attention to the most important of them. —*London Horological Journal.*

Neuchatel Observatory Trials.

Ed. Horological Journal:

Pocket chronometers on trial in an Observatory can be kept in constant external motion by mechanical means, from the mildest "man of leisure" usage, to that of the roughest railway shake. The machine wearer of watches is kept in motion by weights, and wound like a clock. I use it occasionally ever since 1862, and have several times sent letters concerning it; but here matters ended—no doubt it was considered of little value. I said, in substance, that such an automaton watch wearer is as necessary to watchmakers of pretension as the indispensable regulator, because testing watch escapements in the stationary condition, *proves nothing;* every artist must know this, if he reflects a little, as the balance is not influenced;

and, under such circumstances, the pendulum spring has advantages that even the pendulum *has not got*, and *cannot have*. The question may be asked, how such machines are made. I will only answer by saying that here is an opening for genius to exercise itself, and an extremely important one, because there are three kinds (conditions) of isochronism, two of which must be *separately* tested in the machine; and this could not be done in portability (real pocket), hence I consider my artificial watch pockets vastly superior for tests of merit in an escapement, to the *real* ones, as any class of external motions can be isolated. M. Saunier's theory in the last number of volume three, Horological Journal, *is ten years in practicc in America*.

J. Muma.

Hanover, Pa.

——o——

Exercise for Watchmakers.

Ed. Horological Journal:

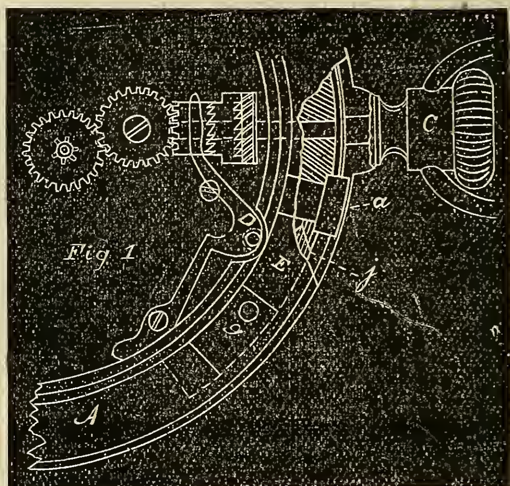
I want to say a few words to your readers on a subject to which I think, as a general thing, too little attention is paid by watchmakers; that is, on the practice of taking too little daily exercise for the *upper* part of the body; and as a consequence, when one looks at a watchmaker he will generally see a round-shouldered, hollow-chested man. When I went to work at my trade I became very round-shouldered indeed; so much so that it was considered necessary that something should be done to correct the evil; so shoulder braces were recommended and tried without avail. After thinking the matter over I went into gymnastics, and no sooner did the muscles of my chest and shoulders begin to strengthen and develop than a change came over the scene, and in a very short time it was wonderful to see how I straightened up, and my shoulders went back as God intended they should be, and now I carry myself as erect as any other man. A high bench is a good thing, but with a little exercise it will not be such a task to keep the body erect. In my experience I find a pair of Indian clubs used a few minutes morning and evening very good. Try it and don't take the word of your friend, but prove it.

James S. Kelley, Jr.

Minneapolis, Minn.

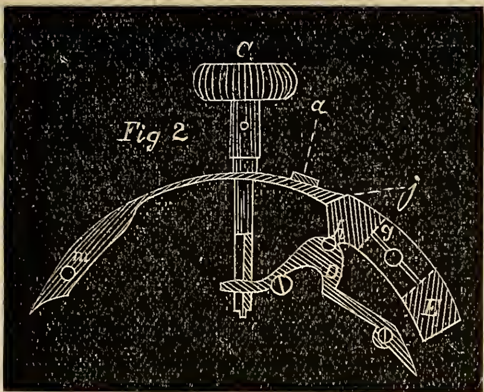
New Inventions.

Improvement in Stem-Winding Watches.—*Borel & Courvoisier, Switzerland, Assignors to Quinche & Krugler, New York.*—Various plans for disconnecting the hand and winding mechanism from each other by closing the case, have been introduced, making it impossible for the owner of a watch to get it back in his pocket without making the requisite disconnection, unless he was so beside himself with obliviousness or something else, as to get a hunting-case in his pocket wide open, which the most gross carelessness could hardly accomplish. Messrs. Borel & Courvoisier, of Neufchatel, Switzerland, have recently secured Letters Patent on a plan for accomplishing the purpose, which seems an ultimatum in this direction. The drawings will give a clear insight into the arrangement.



It has the usual push *c*, and the double ratchel clutch sliding on the square when actuated by the spring lever D, which ordinarily is held in contact with the hand-work by a small push coming out through the case at *j*, but in this case a slide E, within and under the flat rim of the case A, and held in place by the knob and slide *g* (outside the flat rim of the case), is made to force the lever D inward by means of the projecting lug *h*, upon its edge. Its action is this: when the front of the case is opened, and the slide E is forced forward (or toward the pendant), the lug *h* comes in contact with the usual stud upon the lever D, and at once connects the pinion end of the ratchet clutch with the dial wheels, where they would *remain*, but for another arrangement which

constitutes the peculiarity of this patent. The locking spring *m* is peculiar, as will perhaps be more clearly shown in Fig. 2. In addition to



carrying the locking hook *a*, it continues on, terminated by the diagonal face *j*, which lies in contact with a corresponding face upon the slide E. The action of the parts upon each other is instantly seen, for if the push-pin is pushed inward it carries the locking spring with it, the diagonal face *j* forcing the slide E back to its proper position, releasing the spring lever D, and thus insuring the disconnection of the dial wheels with the pinion clutch.

The same action takes place when the case spring *m* is forced inward by the act of shutting the front case, through the agency of the locking hook *a*, thus rendering it absolutely impossible to close the case and get the watch in the pocket without the proper disconnection of the winding and dial work, and that too by very simple means, not easily deranged, and quite independent of the volition of the wearer.

The invention has another favorable feature which will commend it to general adoption, which is, that it is entirely independent of any unusual construction of the watch movement. A large majority of movements in market are of the form here shown, and any of them can have this arrangement, because the peculiar features are in the case itself, and involve only a little change in the manner of springing, and but little or no additional expense over the ordinary methods.

This ought to add (if it were possible) to the already large demand for the Borel & Courvoisier watch, which has achieved a position among foreign competitors for American favor creditable alike to the intrinsic merits of the movement, and the courteous manner of dealing and shrewd business tact of the American agents, Messrs. Quinche & Krugler.

Improvement in Pen and Pencil Cases.—*Joseph Monaghan and Thomas Flynn, New York.*—This improvement relates to pen and pencil cases in which both pen and pencil project from one and the same end, and an extension from the other end forms a holder. When moved out or in, the pencil may be locked by partially revolving the holder which forces a pin into one of the lateral notches. This construction is very simple and cheap, and admits of making the cases much shorter than they now are for the pocket, and yet longer when extended for use as a pen holder.

John P. Allen and W. E. Banta, Springfield, Ohio.—Improvement in watch regulators by which the least movement of the indicator shall at once and invariably affect the hair-spring and not be consumed in lost motion, which must necessarily be where cogs or gears are used; also the use of round teeth in the segment, and small spring projections on the indicator hand which clasp and embrace the tooth on its opposite sides so that the tooth may roll between the spring jaws without any loss of motion.

Improvement in Spring Boxes.—*John P. Allen, Springfield, O.*—The object of this invention is to prevent accidents from the recoil of the spring box when the mainspring breaks. This is done by the peculiar connections between the body of the spring box and its head or top plate, which so long as they move in the proper direction are held together by three equidistant hooked projections upon the one, which fit into three corresponding bevelled holes or slits through the other, so arranged as to draw the two parts more closely together when the wheel is in motion, but instantly separate by a reverse motion, raising the head plate and instantly disconnecting it from the body portion, and throwing it out of gear with the train, thus preventing damage to any part of the train in case the mainspring breaks.

Joint for a Broach.—*D. O Stanley, Sout Attleborough, Mass*—Easier in construction, cheaper and stronger than the usual form.

Improved Fastening.—*L. C. Cahn, N. Y.*—Method of fastening the ornamental padlock, which is attached to a watch chain in place of the ordinary vest hook.

Gold Chain.—*J. H. Smith, Brooklyn.*—A method of constructing flat gold chain similar to the "roller" chain, avoiding the necessity of using solder in putting together.

Watch Key Swivel and Hook.—*Allen & Croft, Springfield, Ohio.*—Intended as a useful ornament for a vest chain.

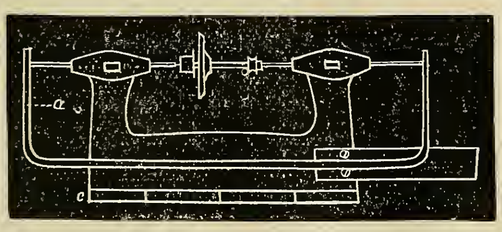
Combined Watch Key and Cork Screw.—*L. J. Jenner, Chickopee Falls, Mass.*

Improvement in Electric Clocks.—*V. Himmer, New York.*—Assignor to himself and Gustave Autenrieth. See page 31 of present No. of the Journal for description.

Answers to Correspondents.

M. M. N., Conn.—Certainly, you can make a very good tool for facing pinions or the shoulders of pivots out of a depthing tool.

Upon one of the jaws you must screw a brass or steel plate, the end projecting beyond the tool far enough to allow it to be screwed into the jaws of the bench vice. The centres in one jaw can then be used to carry an arbor with a brass pulley on one end for the drill bow. On this arbor you can fasten, or slip on pinch tight, a metal grinding disk, or what is perhaps a better arrangement, you can use the ordinary screw arbor, and fit to it as many grinding and polishing disks as you choose. This arbor is placed between the centres of the depthing tool, which are kept in contact with the ends of the arbor by a brass or steel yoke *a*, so bent



that the pressure shall keep the arbor in place and yet allow the yoke centres and arbor free lateral motion as a whole. The pinion, or whatever else to be operated upon, is placed between the other pair of centres in the tool, and the proper depth obtained by the adjusting screw, and then the polisher moved longitudinally along till in easy contact with the face of the pinion. With a drill-bow the grinder or polisher is rotated, which in its turn rotates the pinion with which it is in contact, the constantly changing points of contact between the two surfaces rapidly producing a perfectly flat surface, which can then be glossed by a polishing disk, actuated in the same manner. For many purposes the repairer will find this arrangement very convenient.

A. R., *Holliston, Mass.*—The ringing noise which you mention as produced by the hair-spring, must be occasioned by the hair-spring suddenly leaving one pin and as suddenly striking the other, and may be produced by two causes. Usually the very remedy which you applied to cure the difficulty is the cause of it, namely, oil which by some chance has become attached to the hair-spring or to the pins in the regulator, and has remained so long as to be a little glutinous or adhesive; consequently the spring attaches to it until the tension of the spring overcomes the adhesion, and it suddenly breaks away and recoils upon the opposite pin with an increased velocity which is equivalent to a blow upon the tempered steel of the spring, causing the peculiar ringing sound which you noticed. Your assertion that the least touch of oil between the pins prevented the noise, should have led you to suspect the cause, and your remedy, in the course of time, when the oil which you applied becomes adhesive, will only aggravate the difficulty. The fact that the sound is only sometimes heard is accounted for by the fact that the excursions or oscillations of the balance are not always the same, and, under the unequal motions which handling gives them, the spring may not at some instants be opened out, or closed up sufficiently to press upon either pin with the force necessary to make it adhere. Critically speaking, this does affect the rnnning of the watch, particularly when the adhesion is not constant; for then the amount of this force is not constantly in action, and the effects of the spring's tension upon the vibrations of the balance must be as variable as are the sounds you hear produced. Still in a watch of any other than extraordinary workmanship, there are other sources of error which would entirely conceal the minute results that this trifling defect would cause, and I very much doubt whether you would be able to detect any difference in rate whether your watch did or did not have the ringing sound you mention. There is a similar metallic ringing or singing sound sometimes

observable in watches, but constant and attendant upon each vibration of the balance, which is occasioned by the spring very slightly touching the bottom of the space between the pins, and scraping along from one pin to the other, particularly if the bar between the pins is roughened by file or stone marks. This is remedied by setting the spring away from contact with the metal.

W. G. M., *New York.*—We entirely agree with the remarks you make on the subject of compensating pendulums. It is of the utmost importance that you and all others engaged in constructing new forms of compensation should not only be masters of all the intricate questions connected with the theory of the pendulum, as well as the disturbing influences the various escapements have on the regularity of its vibrations, and also that you should be familiar with the laws that govern the action of heat on various substances. The suggestion is made by "Clyde," that, in consequence of the difference in the quantity of latent heat that is known to exist in mercury and steel, a cold atmosphere at the lower end of a pendulum is rather advantageous than otherwise to the mercurial form of compensation, and we believe these laws to be founded simply on a study of the laws of heat, and not from any actual experiment.

We are glad that you feel interested in the proposed experiment to determine the general difference that exists in the atmosphere at the two ends of a pendulum in the position in which standard clocks are usually situated. By the end of January ample opportunity will have been afforded to try the experiment in the winter as well as in the summer months, at which time we shall be happy to receive a report of your experiment, and we will give it due publicity along with all other reports we may receive. The rules proposed to be observed in conducting the experiment are given at the end of an article on this subject in another part of the JOURNAL.

G. H. L., *Baltimore, Md.*—The chains you mention *are* machine made, and more perfect than it would be possible to make the same kind by hand. The chain is known among the trade as "Adelaide," and the machine that makes it is one of the most ingenious, as well as complicated, of all the modern automatic machines in use. It was invented by Mr. L. Towne, one of the firm of Sackett, Davis & Co., and they have recently renewed the original patent, in combination with several improvements which many years of use have suggested. The inventor has had the charge of construction, as well as their superintendence from their first introduction. Owing to the perfection of workmanship required in them, only one serious attempt has ever been made to manufacture chains by the same mode. The products of this one were so inferior that its use was confined to making the cheapest of brass chains, until suppressed for infringement. So far as known, all the machine-made chain in use comes from these machines. Immense quantities are consumed by all classes of manufacturers of jewelry in making the fringes and tassels so much in vogue. When the chain is to be colored it is used just as it comes from the machine; when to be used bright, it requires the subsequent operation of being "lapped," which gives to each of its eight sides the fine polish so peculiar to lapped gold. The firm mentioned have in operation, to supply the American demand, from twelve to fifteen machines, and in Germany, Messrs. Steinheur & Co. have six of these machines in use, under license from Messrs. Sackett, Davis & Co.; and from their factory at Hanau, and the market at Leipzig, the continental trade is supplied by them.

The machines have also been introduced in England. Within the past month Mr. George Hazeltine communicated to the London Society of Arts, the fact of his having introduced into the Kingdom and patented the first machine of the kind, in 1857; and that it was invented and principally constructed in America. He sold it to a manufacturer in Birmingham, and that through them many fortunes had been made. His original one cost less than £50, and performed the work of 70 operatives in a superior manner, and he frankly and truly gave the credit of the invention to America, and stated that it was owing to their patent laws that it had been successful in Great Britain.

X. Y. Z., *Miss.*—"Doublets" are made to imitate real stones. "Paste" is not hard enough to receive the proper polish upon its facets, nor will it endure the hardship of constant use; consequently the fronts of "doublets" are real stone cemented to a paste back. These fronts

may be a thin layer of the real stone it is intended to imitate, or it may be a front of some transparent stone which will receive its hue from the paste back to which it is cemented. The readiest way for you to detect the deception is by the file, which will not touch the front, but will easily scratch the rear of the suspected stone. Ruby, emerald, and sapphire are the stones usually found as doublets. It does not pay to thus imitate the cheap stones. Another class of imitations are the pastes—"strass," a soft glass which is easily detected by its softness under the file.

Every few months the papers set going afresh the old story that some "French savant has succeeded in making real diamonds, rubies, sapphires, or something else, and that there is immediate prospect of their becoming so common as to be comparatively worthless." Probably no man has devoted more years to the study of the possible artificial production of gems, than M. Gaudin, who has communicated to the French Academy some curious observations upon the effect of the oxy-hydrogen blow-pipe. He says that alumina alone will not do for the production of precious stones, owing to its tendency to de-vitrify again, becoming fluid at once, and then volatilizing, like camphor. In order to render it viscid, quartz must be added, but that impairs both its crystallization and its hardness. The coloration or tinting of artificial stones is also another difficulty in the way of their production, as the intense heat of the oxy-hydrogen blast acts on various substances in quite a different manner from the furnace. Copper resists its action better than any other metal, and by dexterous manipulation can be made to produce many different colors; manganese and nickel yield, at high temperature, orange and yellow. These artificial stones are more difficult to produce in the crucible than by the blow-pipe, the latter mode alone producing those that resist the file. All anticipations of the speedy productions of artificial stones of any value, will be disappointed.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For September, 1872.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be Subtracted from Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Sunday	1	64.39	0 17.14	0.786	10 43 49.30
Monday	2	64.35	0 36.11	0.797	10 47 45.85
Tuesday	3	64.31	0 55.36	0.808	10 51 42.41
Wednesday	4	64.27	1 14.87	0 818	10 55 38.96
Thursday	5	64.24	1 34.62	0.827	10 59 35.51
Friday	6	64.21	1 54.59	0.836	11 3 32.07
Saturday	7	64.18	2 14.78	0.845	11 7 28.62
Sunday	8	64.15	2 35.15	0 852	11 11 25.17
Monday	9	64.12	2 55.71	0 860	11 15 21.72
Tuesday	10	64.10	3 16.43	0.866	11 19 18.28
Wednesday	11	64.08	3 37.29	0 871	11 23 14.84
Thursday	12	64.07	3 58.27	0.876	11 27 11.39
Friday	13	64 06	4 19.34	0 881	11 31 7.94
Saturday	14	64.06	4 40.49	0.883	11 35 4.49
Sunday	15	64.06	5 1.71	0 885	11 39 1.05
Monday	16	64.06	5 22.95	0.885	11 42 57.60
Tuesday	17	64.06	5 44 20	0.885	11 46 54.15
Wednesday	18	64.06	6 5.42	0.884	11 50 50.71
Thursday	19	64.07	6 26.62	0.883	11 54 47.26
Friday	20	64 08	6 47.77	0.879	11 58 43.81
Saturday	21	64.10	7 8.80	0.875	12 2 40.36
Sunday	22	64.11	7 29.73	0.869	12 6 36.92
Monday	23	64.13	7 50.53	0.864	12 10 33.47
Tuesday	24	64.14	8 11.17	0.857	12 14 30.02
Wednesday	25	64.17	8 31.66	0.849	12 18 26 58
Thursday	26	64 20	8 51 94	0.840	12 22 23.13
Friday	27	64.23	9 12.01	0.831	12 26 19.69
Saturday	28	64.26	9 31.85	0.821	12 30 16.24
Sunday	29	64.30	9 51.43	0.811	12 34 12.79
Monday	30	64.34	10 10.74	0.799	12 38 9.34

Mean time of the Semidiameter passing may be found by subtracting 0.18s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
●	New Moon	2 12 53.3
☽	First Quarter	10 2 3.5
○	Full Moon	16 17 4.7
☾	Last Quarter	24 1 21.7
		D. H.
☾	Perigee	14 16.4
☾	Apogee	26 13.8

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION. D. H. M. S	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus	1 11 33 44.21	+ 4 17 16.2	0 49.9
Jupiter	1 9 20 22.15	+16 13 3.4	22 33 6
Saturn	1 19 4 33.73	−22 29 15.6	8 19.3

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CONTENTS.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER XII.—[Continued.]

155. If there be any way of overcoming the inconveniences in the construction of keyless open-faced watches, it must be found in the employment of another system of transmitting the winding power. As long as flat, bevel, and contrate wheels are exclusively employed, the difficulty can only be eluded by a construction just as vicious as the before-mentioned ones. A combination of an endless screw and one or two angular gears seems to afford a greater liberty of disposition; but I have not seen as yet a commendable construction of this kind. It seems the idea has not yet been sufficiently eliminated.

The source of difficulty lies evidently in the following circumstances:

If the winding operation is to be performed with a certain moderate number of revolutions of the winding knob (159), a very small wheel on the barrel arbor must be selected for receiving the action of the screw; but then the place for this latter must be granted above or under the barrel, and this necessarily increases the height of the movement. If, on the contrary, the wheel on the barrel arbor is large enough to admit the screw gear beyond the circumference of the barrel, the winding would be so excessively slow as to necessitate a transmission of power by a multiplicative train.

156. Lately I have succeeded in combining an open-faced keyless movement with greater ease in the arrangement of the train, by having a rocking platform under the dial. The pendant and barrel are at an angle of 45°, taken from the centre, and the sizes of the train wheels are quite normal. The third wheel is fastened to a collet on the lower end of the pinion arbor, and moves in the space between the barrel head and the lower bridge. This space is quite sufficient for having the barrel and the third wheel amply clear of each other, and on the other side of the barrel the centre wheel is placed quite in the usual way. A movement on this plan is hardly any higher than a key-winder of the same breadth of mainspring.

158. It remains now to speak of some other designs for winding, in which the force is not applied by the pendant. There were some old watches with a kind of keyless action by turning the dome of the watch case. This, however, has found no followers, in consequence of the impossibility of a dust-proof adjustment of the case, and because there were no means of setting the hands except in the usual way by using a key.

Other inventors had a circular rack, operated on by a slide projecting from the outside of the case, then winding by an intermittent or reciprocating motion.

Others, again, utilized the up and down motion of the front cover of a hunting case for winding up a small part of the spring, on the supposition that a hunting watch will undoubtedly be opened a certain number of times dur-

ing the day, and thus be kept agoing. It is not difficult to estimate the value of an arrangement based upon such suppositions for its efficiency. It is the next thing to those old self-winding watches which were wound through the motion imparted to them by the walking of the wearer, and which required a good long walk every day for being kept agoing; or, instead of this, a good while of shaking up and down.

159. When constructing a keyless mechanism, it is very desirable to establish a certain relation between the turns of the winding knob and those produced at the barrel arbor. In the greatest part of carefully made keyless watches each revolution of the winding pinion operates one-third of a turn of the barrel arbor, or nearly so. This is a proportion which ought not to be much deviated from, in whatever direction, for if a greater speed is given to the winding, the operation is too hard to perform, especially for tender fingers. If, on the contrary, the winding effect is distributed over too great a number of turns, the action will be very easy, but at the same time a greater power is put into the hands of the person winding, and this power may prove fatal to the acting parts, if not used with the appropriate discernment. Especially the end of the winding operation, in such cases, is attended with dangers for the stop-work, the teeth of barrel and centre-pinion, etc. With the rocking bar mechanisms, the relation of turns is simply in the ratio of the numbers of the winding pinion and the barrel wheel.

But the other group of keyless works having a multiplication of speed by the flat wheel moving on the axis of the contrate wheel, the ratio between the numbers of these two must be taken into calculation. If, for example, the winding pinion has 12 teeth, the contrate wheel 24, the flat wheel on it 40, the barrel wheel 60 teeth, the result will be: $\frac{12 \times 40}{24 \times 60} = \frac{1}{3}$; that is, one revolution of the pinion operates one-third revolution of the barrel arbor.

160. There is another danger resulting from violent winding in those watches which have a large winding wheel with fine teeth, or the click-work acting in the teeth of this wheel. The immoderate winding effort, suddenly cut off by the action of the stop-work, and generally at the opposite end of the barrel arbor, produces a small degree of torsion of this latter, and one more tooth of the wheel is forced to pass the click. From this moment the watch acts under the influence of the full power of the mainspring, increased by the reaction of this torsion transmitted by the stop-work, and begins to bank violently, and often continues so for some minutes. This is always accompanied with no small danger for the acting parts of the escapement, and in case of no lasting injury to the watch, it produces a considerable deviation of rate.

Many a good keyless watch, when carefully treated, with an irreproachable rate, has been discredited by irregular performance, resulting from rough treatment in winding.

161. A very simple remedy against this inconvenience consists in giving the click a small amount of shake on its screw or stud. The recoil resulting from this shake is sufficient to ease any torsional strain of the kind above described.

I have also made keyless watches with an extra ratchet underneath the large winding wheel on the barrel arbor, and found them answer quite well. The ratchet was taken off the size of that in a key-winding watch, and, with rather vigorous teeth, it has sufficient recoil to make up for any torsion. The room for this ratchet is abundant, and the tail of the click, if made rather long, allows for letting down the spring without taking off the barrel wheel. A click-work of this kind never causes any trouble in casing, while those click-works which are laid in the level of the winding wheels, and at the edge of the larger ones of them, sometimes are troublesome to get clear from the dome of the case.

162. The movement of a keyless watch ought not to be charged with any extra friction of moving parts, if it can be avoided. In some watches of this kind the motion work has to carry with it one or two setting wheels, and sometimes a pinion, all of them adjusted in a way which does not reduce friction to its least amount. As soon as one of these stop screws has been overlooked, when the repairer provides the movement with oil, the friction created by it will bring the watch to a stand-still, especially when the sink for the screw's head fits rather closely. All these accessories ought to be brought into action only in the moment of

setting the hands, and should recede and leave the motion work entirely free. Care must be taken that the setting wheel acts in the direction of the centre of the minute wheel when pushed into gear. The teeth of this wheel, too, ought to be pointed and thin, so that its entering into gear causes no sudden displacement of the hands if the teeth of both wheels chance to meet with their points.

———o———

Our Regulator.

"Do you regulate that clock by the sun?" said an old gentleman, as he glanced at the imposing regulator in the shop of a friend of ours. "No," blandly replied the owner of the machine, as he removed the glass from his eye and gave a final twist to the movement he had in hand, "we regulate the sun by that clock; don't you see '*Regulator*' on the dial?"

It is probable that many of the members of a profession whose *movements* are so entirely guided by the sun, even if they do not, like our aspiring friend, essay to regulate his motions by their own wheel-work, or to substitute for the well-known columns headed "clock fast" and "clock slow," in the almanac, the words "sun slow" and "sun fast," may take an interest in the recent discoveries relative to that marvellous globe. In hopes of gratifying this taste, we have made a few extracts from a pamphlet recently published by C. C. Chatfield & Co., of New Haven, containing a lecture by Prof. Young, of Dartmouth College, who is admitted to be the best American authority on this subject, and whose horological studies have been referred to in previous numbers of the Journal.

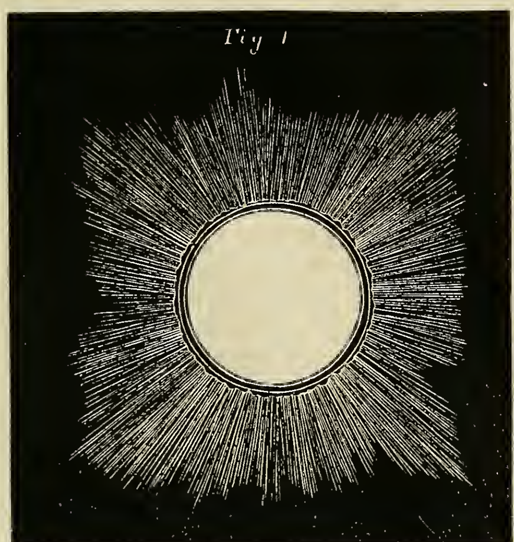
The first and most important matter relating to the sun is his distance; of this Prof. Young says: "I do not suppose that, in stating the distance of the sun as ninety-two millions of miles, I have communicated to you any real notion. Probably I might just as well have said ninety-two billions. The conception is too vast to be fairly grasped by the human intellect, but perhaps one or two illustrations may assist in the matter. If, on some intramundane railway between the earth and the celestial metropolis, the Pilgrim Fathers had started from the sun at the same time when they really left England, and if they had travelled by special express, at the rate of forty miles an hour, without stops, they would not yet have arrived, nor would their train be due until 1883—363 years upon the road! At the present time, with only eleven years more to go, they would still be sixteen times as distant as the moon; so remote that the earth would be to them only a brilliant planet, of about one-fifth the moon's diameter. * * * If sounds could travel through celestial spaces at the same rate as in our air, then the thunder of a solar storm, or the report of an explosion such as occurred last September, might reach us in a little more than fourteen years." And yet across this tremendous chasm, which it appalls the mind to contemplate, the sun exercises his lordship and performs his service; every pulsation of the solar surface being instantly responded to upon the earth.

"What, then, is this body so distant and yet so potent? But first, a word as to its size. Its diameter is 860,000 miles, nearly 109 times that of the earth; but, although so much larger, it is lighter, bulk for bulk, than our earth; or, in other words, its density is only one-fourth that of the earth,—about $1\frac{1}{2}$ times that of water. Were our earth to be placed at the centre of the sun, there would be space for the moon to revolve at her proper distance from us, and yet be thousands of miles from touching the encircling globe. When looking at the moon some bright evening, imagine yourself at the centre of a vast spherical shell, the inner surface of which is almost as much beyond the moon as she is distant from you, and you may get a faint idea of the sun's magnitude.

"It would at first seem that the remarkable lightness of the solar substance, and the great power of solar gravity, can be reconciled only by supposing the sun to be in the main a gaseous mass, a mere cloud of vapors; towards this conclusion also many other facts converge, such as the intensity of the solar temperature, and the peculiar motions observable upon his surface. At present this may perhaps be regarded as the prevailing opinion among men of science,—only an hypothesis, however, not yet by any means fully established." * *

Many attempts have been made to measure the solar temperature, but with no satisfactory result, the estimates varying from 3,000 to 100,000 degrees Fahrenheit.

"But though the *temperature* of the sun is thus uncertain, it is not so with the quantity of heat emitted, which is quite a different matter. Sir John Herschel ascertained that the heat received by the surface of the earth from the sun in the zenith, would be sufficient to melt a layer of ice one inch thick in about two hours and twelve minutes. Hence it follows that if the sun were surrounded by a shell of ice 134,000-000, of miles in diameter and one inch thick, the ice would be completely melted in two hours and twelve minutes. To produce this effect by the burning of anthracite coal would require a a layer 13 feet thick all over the sun to be consumed every hour,—two-thirds of a ton per hour to every square foot of surface,—such a fire as no earthly furnace can ever parallel. At this rate, if the sun were made of solid coal, he would burn entirely out in less than 6,000 years. And now come such questions as these: What maintains this tremendous furnace; what is its fuel; for how many ages has it blazed as now, and when, if ever, will come the day of its extinction? I cannot answer any of them, nor can any one, I think, with certainty in the present state of science. So far as can be ascertained from facts of observation, it is impossible to assert that the sun is growing either hotter or colder."



The subjoined cut (Fig. 1) will serve to explain the names given to the different portions of the sun. The space between the two inner lines is called the "photosphere;" between those lines and the ragged one is the "chromosphere." The radiating portion outside of all is the "corona."

Of the various theories relating to the photosphere, or visible surface of the sun, that most generally received is that "it is a stratum of luminous clouds. It is supposed that when the vapors of the different substances contained in the solar atmosphere are exposed to the cold of outer space, partial condensation takes place, and clouds are formed, just as they are in our own atmosphere; but while our clouds are made up of minute drops of water, these solar clouds must be composed of drops of melted metal. * * It is difficult to ascertain with much accuracy the thickness of this luminous shell, but from some peculiarities in the motion and appearances of the spots it is usually estimated at from 3,000 to 8,000 miles." On this

photosphere are the spots (one of which is shown in Fig. 2) which are the most familiarly known of any of the peculiarities of the sun's surface. Both in number and size they vary within very wide limits, portions of the sun seem at times to be covered with them, like the face of a person with freckles; again the whole disc will be almost entirely free from them. In size they vary from 400 or 500 miles diameter to as much as 50,000 or 60,000 miles diameter, through the most common of which our earth would drop like a pea through a ring.

"And now as to the nature of the spots: What are they? One thing is settled beyond question,—they are cavities in the photosphere; but whether they are orifices reaching clear through this stratum and revealing some less luminous core below, as the Herschels have held, or whether the central umbra is formed by a mass of comparatively dark and opaque vapors collected in a simple hollow; or whether, as Zöllner holds, the umbra is a floating slag upon the liquid shell, which he believes to underlie the photosphere, is as yet doubtful. * * It is reasonably certain that directly

above the umbra or darkest part of the spot there is a strong vertical current in the solar atmosphere, and this produces a powerful in-draught towards the centre of the spot along the surface of the photosphere, and in that cloud stratum itself. But whether this vertical current ascends or descends is still uncertain.

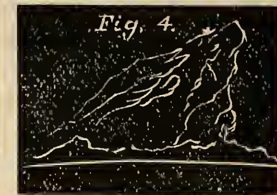
"The spots pass across the sun from east to west in about a fortnight, and it has been attempted to deduce the period of the sun's rotation from their motion; but it is found impossible to obtain a reliable result, because the spots themselves are drifting, and that to some extent systematically; those near the solar equator indicate a rotation period of nearly 25 days, while at latitude 44° it is 28 days. The probability is that the sun, not being solid, has no one period of rotation, but different parts of its surface and of its internal mass move at different rates."

Want of space compels us entirely to omit Prof. Young's interesting account of the spectroscope and its application to the sun.

Exterior to the photosphere is what was named by Dr. Frankland, the chromosphere; *i. e.* color sphere. "At the total eclipse of 1842 many of the observers noticed strange rose-colored objects hanging upon the outline of the moon. Some called them 'red flames,' others preferred the non-committal name of 'prominences,' or 'protuberancces,' and at once a brisk discussion arose as to their nature and location. * * It was not until 1868 that their true nature was made known, and then by the spectroscope. * * The only reason why we cannot see these prominences under ordinary circumstances is simply this: the air in the neighborhood of the sun is so intensely illuminated as completely to mask them; if we could only devise some means to weaken this air-light, without much affecting their own luminosity, we could see them well enough at any time."

This is precisely what the spectroscope does.

"The chromosphere is from 6,000 to 10,000 miles thick on a average, but varies greatly, especially in the neighborhood of spots. Over the centre of a spot there is often a well-marked depression, but at a little distance the surface is elevated and violently disturbed. Everywhere, indeed, its upper surface is ragged and uneven in the extreme, so much so as to suggest the idea, which is maintained by Proctor, that it is not a stratum at all, but made up of many separate jets of heated hydrogen issuing through orifices in the photosphere. * * The chief interest of spectroscopic observation on ordinary occasions centres in the prominences. (Two of these are shown in Figs. 3 and 4.) * * *



These vary greatly in appearance and magnitude, as much as our terrestrial clouds, but may be roughly divided into two classes, the eruptive prominences, and the cloud-formed. The latter are not very brilliant, but are comparatively permanent, and frequently of great size, from 20,000 to 80,000 miles in height, and of even greater length. In structure they are generally cirriform, made up of little wisps and filaments, whose delicate beauty defies description and delineation.

"The eruptive prominences aro very different and far more active; they are often mere streams of intensely brilliant light which rise straight and sharp, but commonly inclined to the vertical. Not unfrequently they attain a height of 15,000 or 20,000 miles in a few minutes. * * Often wo find them resembling in shape gigantic mushrooms, sometimes great pyramids, and at others the smoke of a distant steamer. The whole appearance of this class of prominences indicates almost irresistibly that they are formed by the ejection of gaseous matter through orifices in the photosphere. As Zöllner shows, the difference of pressure between the inside and outside of the orifice through which the gas is driven must be simply enormous to account for the observed velocities, which *often* exceed 100 miles per second, and, as Proctor shows, may occasionally be 500 miles in a second, where heights as great as 200,000 miles are reached in a few minutes. The maximum velocity of a cannon ball is twelve hundred times less than this. No explosive now known to human chemistry could hurl a missile with a velocity in any way even remotely comparable to this. It would follow, further, that if any denser material was ejected from the bowels of the sun by this

explosion, as I think it may fairly be called, it would never return to the sun again. It would fly off into space and might possibly descend upon the earth as a meteor. In this view, as Proctor suggests, it is by no means impossible that some of the specimens of meteoric iron in our cabinets are really *pieces of the sun.* The forms and motions of many of the prominences are such as to show that they float in an atmosphere of different material and lower density, in which there are winds of great violence, and sometimes whirling storms like those in our own atmosphere. Not unfrequently the top of a prominence, which appears to be quiet at its base, is torn to pieces by contending currents which snatch off shreds and carry them away with enormous velocity. * * As to the nature of this atmosphere, we as yet know comparatively little, for it is only directly visible at the time of a solar eclipse. This brings us to the Corona, the crown and halo of glory which, during an eclipse, encircles the sun. If, on such an occasion the sky is clear, the moon appears of almost inky blackness excepting a little diffuse light around the limb—just enough to bring out her rotundity in the most striking manner; close around its outline lies a ring of pearly greenish light of almost dazzling brilliance at its inner edge, where it contrasts with the still more brilliant prominences, which blaze like burning rubies. It gradually fades out towards its outer edge, at a distance of from $\frac{1}{4}$ to $\frac{1}{2}$ the moon's diameter, and is terminated by an irregular and very indefinite boundary, which is usually roughly quadrangular. It is always distinctly radiant in its structure, made up of filaments which stand nearly perpendicular to the surface of the sun, and yet in many places are strangely curved and intertwined."

The foregoing is a very meagre outline of Prof. Young's lecture. Those feeling an interest in the subject will find themselves amply repaid by reading the entire pamphlet.

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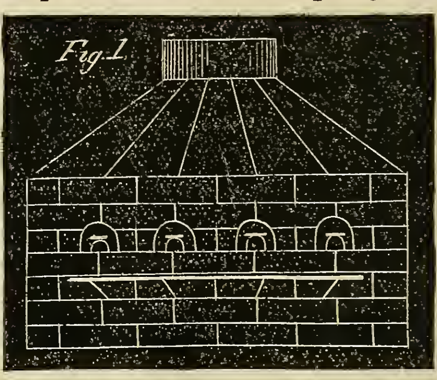
To My Brother Watchmakers.

My son Henry left me in 1869, and since that time I have not heard from him. Should any one be able to give me a trace of him, or of his death, and will state this fact to me, I shall be ever grateful.

W. Zilliken, 135 Centre Av., Pittsburgh, Pa.

Watch Dials.

One of the most artistic operations connected with the watch manufacturer's art, is the making of dials. Artistic skill and long practice are required, both in the enamelling and in the painting. In the first vol. of the Journal (now out of print), a description was given of the present mode of their manufacture; a recent examination of the processes at the U. S. Factory, at Marion, has revived a subject that may be interesting to later subscribers. The basis of all dials is *pure* copper. From a sheet of the proper thickness, round blanks are punched; these have punched through them three holes to receive the dial feet, also of copper, and the centre and seconds hole. The centre and seconds hole are not cleanly punched, but have a bar of projecting metal raised around them of sufficient height to prevent the fluid enamel from flowing into the hole. A shallow rim is turned up around the edge of the dial and the feet firmly riveted into their places, and it is then ready to receive the enamel, which is but a fine variety of porcelain, especially prepared for this purpose, and is somewhat more fusible than the ordinary porcelain. This enamel is imported in cakes or masses, and is then broken up and ground to an impalpable powder in an agate mortar, then levigated, to graduate the quality and remove all the impurities. The coarser quality is used



for filling the back of the dial plate, giving firmness and strength to the dial. This fine porcelain powder is then spread in a thin layer upon the dial plate, and gently heated to expel the moisture.

The enamelling furnace is a miniature cupola into which are set fire-clay muffles of a foot or so in depth, and six inches in height. These

are surrounded with coke as fuel, and an air blast supplies the draft. Within these muffles are set little semispherical cakes of fire clay, and resting upon their rounded surface are small thin plates of fire clay, which are the tables on which the dials are placed for baking. These simple arrangements give an easy method of regulating the baking operation with the greatest nicety, for the heat must be constantly watched so that the requisite degree of fluidity of the enamel is obtained, and at the same time the copper must not be melted. This is done by moving the base which supports the table and the dial farther in or out of the muffle, as circumstances may demand, the heat at the inner end being much more intense than near the mouth. The spherical surface on which the table rests also subserves another very important office; the dial, while covered with the melted enamel, must be kept horizontal, otherwise it would flow to the lower side, and, if it did not overflow, would give a thicker layer on that side than the other; but by moving the dial upon the table, which is itself poised upon the convex surface, an exact level can be obtained. This is done by the eye of the workman, which is constantly on the work while in the oven. All the handling of the red hot contents of the muffle is done by light tongs about two feet long, the jaws flattened vertically at the end, so as to seize the dial at its edge as between a thumb and finger.

Before applying the enamel the plate is carefully cleaned with acid, and if by chance any specks of oxidation are left, they must be scraped out, else they will be sure to discolor the enamel. The back being first coated with such as is a little more infusible than that used on the front, and melted on, the front recess is then filled and dried, then placed in the muffle and liquefied by heat till it flows evenly over the whole surface; at this moment it is dexterously taken out by the tongs and set upon the iron which runs along a shelf in front of the mouth of the muffles to cool. If any deficiencies are observed, a little dry enamel powder is supplied to the defective parts and replaced in the muffle. The surface of the dial, after this process, will necessarily be a little uneven; it is therefore faced down by a few rubs upon a flat table of coarse emery, and then a thin layer of the finest and whitest ground enamel spread over and rapidly heated till it flows like a varnish over the whole surface, covering it with a beautiful glaze.

From the enameller it goes to the painting room, where the lettering is done. The blank white dial is placed on a centre-pin in a division-plate of about 4 inches in diameter, marked off into 60 equal parts at its circumference; a steel straight-edge, in line with the seconds hole and the centre of the dial, shows the position of XII., VI., and a line is drawn with pencil on the white enamel surface. The plate is then moved one division, and a short pencil-mark shows the position of the minute lines, every fifth line being drawn through and marking the hour positions.

The dial is thus rapidly divided, and the next process is to cut in the figures, or "chapters," as they are sometimes called. These are painted in black enamel, which is ground to an impalpable powder on a slab, and mixed with some highly volatile oil, which makes a pigment that rapidly dries, leaving the black enamel dust. This pigment is applied to the dial at each chapter, in a dab large enough to construct the figures from, and the straight-edge is again laid along the dial, say over the fig. I.; a flat slip of steel, with one slit in its end as wide as the body of the figure, is then drawn along the straight-edge, scraping off the the black paint, except where the slit allows it to remain undisturbed. For the fig. II. a steel slip with two slits is used, and so on. To make these black parallel marks into figures requires but to cut them off to the proper length, which is done by fixing into one leg of dividers a wooden point, setting the other leg in the centre hole of the dial and striking a circle across them at the top and bottom of the figures, wiping away the superfluous enamel, and the bodies are complete. The hair lines are struck across them by replacing the wooden point with a hair pencil charged with the black enamel pigment, and with it drawing the hair lines. The minute circles are drawn with the same instrument by revolving the dial under the brush. The minute marks, which, up to this point in the process, yet remain in pencil, can now be done by the brush. After careful examination, to be sure that no speck of the black enamel remains upon the dial where it is not wanted,

it is put, for the last time, in the muffle, and the black enamel melted into the white, which forever fixes it there. Dial painting is mostly done by girls, under the supervision of a skilful artist.

At the factory we were shown some beautiful work in the way of enamel painting—a beautiful landscape of the factory buildings and grounds, not omitting the sign upon the front of the building—and all this within the inner circle of the hour figures; also the Lord's Prayer inside the usual seconds dial; and so minute was this lettering, that a strong glass was required, not alone to execute it, but to read it. One of the charms of external appearance which mark most of the American watches is the neat and tasteful dials, and very beautiful effects are sometimes produced upon especial dials, where the graces of elegance are to be added to perfection of time-keeping. Dials for watches ordered for presentation are sometimes ornamented by the process known as etching. This is done by covering the dial with a film of tinted wax, barely enough to protect it from the action of acid. The design to be etched is then drawn through the wax with a steel stilus, which goes through to the enamel at every stroke of the artist. When this labor is completed the dial is subjected for a few moments to the action of fluoric acid, which eats away the bright surface of the enamel, leaving it "dead." The contrast between the polished and unpolished surface produces a delicately charming effect.

The pin holes are lastly drilled, the dial being placed in a "gig," through which each hole is drilled, consequently bringing each hole in the same in each pillar or foot. These dial feet holes, being the last ones to be occupied when the movement is to be put up, are the guide holes for every position the plate is placed in during its whole construction. From first to last they are relied upon for all measurements, and all the fittings which the plate undergoes. In fact they are the only ones which are not at some stage of construction manipulated, and are therefore very properly selected as guide holes.

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Hands.

The hands of time-keepers are worthy of more attention than is frequently bestowed upon them by watch and clockmakers. Their shape and general arrangement, and the neatness of their execution is often taken by the general public as an index to the character of the entire mechanism that moves them; and some are apt to suppose that when care is not bestowed on the parts of the time-piece which are most seen, much care cannot be expected to have been exercised on the parts of the watch or clock which are invisible to the general view. Although we are not prepared to fully endorse the opinion that when the hands of timepieces are imperfect in their execution, or in their general arrangement, that all the mechanism must of a necessity be imperfect also; still we think that in many instances there is room for improving the hands of timepieces, and we beg leave to direct a little more attention to this subject.

In the general arrangement of the hands of watches and clocks, distinctness of observation should be the great point aimed at, and everything that has a tendency to lead to confusion should be carefully avoided. Clocks that have a number of hands radiating from one centre, and moving round one circle—as for instance, centre seconds, days of the month, equation of time, and hands for other purposes—may show a good deal of mechanical skill on the part of the designer and maker of the timepiece; but so many hands moving together around one circle, although they may be of different shades of color, causes confusion, and requires considerable effort to make out what the different hands point to, and this confusion is frequently increased by the necessity for a counterpoise being attached to some of the hands. As a rule time-keepers should be so arranged that never more than the hour and minute hand should move from one centre on the dial. There may be special occasions when it is necessary or convenient to have centre seconds to watches; but these occasions are rare, and we are to be supposed to be talking about the hands of time-keepers in every-day use for the ordinary purposes of life, and also for scientific uses. In astronomical clocks we find the hour, minute, and seconds hand moving on separate circles on the same dial; and one reason for this arrange-

ment is to prevent mistakes in reading the time. In chronometers, especially those measuring sidereal time, the hour hand is frequently suppressed, and the hours are indicated by a movable wheel or ring with figures engraved on it that show through a hole in the dial.

Hour and minute hands should be shaped so that the one can be easily distinguished from the other without any effort on the part of the observer. Probably a straight minute hand, a little swelled near the point, and a spade hour hand, are the shapes best adapted for this purpose, especially if the hands have to be looked at from a distance. There are occasions, however, when a spade hand cannot be used with propriety. In small watches, and clocks having ornamental cases, hands of other designs are desirable, but whatever be the pattern used, or whatever hue of color the hands may be made, it should ever be remembered that while a design in harmony with the case is perfectly admissible, the sole use of hands is to mark the time distinctly and readily. The difference in the length of the hour and minute hands is also an important point in rendering the one easily distinguished from the other. The extreme point of the hour hand should extend so as to just cover the edge of the end of the chapter, and the extreme point of the minute hand should extend so as to cover about two-thirds of the length of the minute divisions. Hands made of this length will be found to mark the hours and minutes with great plainness, and the rule will be found to work well in dials of all sizes. As a general rule, the extreme points of the hands should be narrow. The point of the hour hand should never be broader than the largest stroke of any of the chapters, and the extreme point of the minute hand never broader than the breadth of the minute lines; and in small work it is well to file the ends of the hands to a fine point. The end of minute hands should in every instance be bent into a short graceful curve, pointing towards the dial, and as close to it as will just allow the point of the hand to be free. The minute hands of marine chronometers are invariably bent in this manner, and the hands of these instruments are usually models of neatness and distinctness.

Balancing hands by means of a counterpoise is a subject which requires some attention in order to effect the perfect poise of the hand without detracting anything from its distinctness. In watch work, and even in ordinary clock work, it seldom happens that any of the hands except the seconds require to be balanced, and then there is only one hand moving round the same circle, as is the case with seconds hands in general. We have become so accustomed to looking at seconds hands with projecting tails that we are apt to regard the appearance of the hand to be incomplete without the usual tail; but we must remember that the primary object in view in having tails to seconds hands is, not to improve the look of the hand itself, but to counterpoise it, which becomes an actual necessity for a hand placed on so sensitive a part as the fourth wheel of a watch, or on the scape wheel of a fine clock. When only one hand moves in the same circle, like a seconds hand, the counterpoise may be effected by means of a projecting tail without in any way detracting from a distinct reading of the hand, providing the tail is not made too long, and it is made of such a pattern that the one end can easily be distinguished from the other. In minute hands, however, it is different. These two hands move round the same circle, and a counterpoise on the minute hand is liable at a distance to be mistaken for the hour hand.

The minute hands of large timepieces frequently require to be balanced, especially if the dial be large in comparison to the size of the movement; and in very large clocks, whatever may be the size of the movement, it becomes an absolute necessity to balance the hands. In our opinion, tails should never be made on minute hands, when they can be avoided; and in cases where tails can not be dispensed with, they should invariably be colored the same as the ground of the dial. In almost every instance, however, minute hands may be balanced in the inside, especially if the clock is being all made from the beginning. The minute wheels may be made large, and the one side weighted to balance the hand, or the pinion that moves the hour wheel may be extended through both of the frames, and a long arm attached to it that will work behind the back frame and balance the hand. A great many clocks used for railway and similar purposes in Europe have their minute hands balanced in this manner, and the plan works admirably; for, in addition to rendering

the hands more distinct, the clocks require less power to keep them going than when the hands are balanced from the outside.

Such are our views on the subject of hands, and it will be observed that the whole question resolves itself into one where sound judgment and good taste only require to be a little exercised on the part of the maker in order that all may be able to read the time on our various kinds of time-keepers with ease and accuracy.

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Watch Repairing.—No. 3.

BY JAMES FRICKER, AMERICUS, GA.

As we had the barrel and mainspring under consideration in our last article, it naturally follows that we take up the chain and fuzee in this. Before doing so, however, we will drill the hole in the barrel, if a new one, for the chain hook, which we omitted to do in our last. Of course this is done before the mainspring is put in; the barrel must be first put together, with its arbor in; place it in position in the plates with its bridge screwed on, then with the point of a knife, or other convenient instrument, make a small mark on the barrel, about half the thickness of the chain below the upper plate; take out the barrel and drill a very small hole at about an angle of 45 degrees to the radius, and in the direction to retain the hook of the chain, when the watch is wound; then with a small pivot broach (that will enter the hole) held between the thumb and finger of the right hand, and the barrel in the left, with the hole just drilled on its upper side, insert the broach and depress it as you revolve it, so as to make an oval hole instead of a round one; try the hook of the chain frequently, so as not to get the hole too large.

If the old chain is worthless, and a new one is needed, select one that you think to be about the right thickness; then with the fuzee in your left hand, and chain in your right, fasten the *round* hook to the pin in the fuzee, and carefully wind the chain around it. If the chain goes down to the *bottom* of the groove easily, and yet *fills* it, it is of the proper thickness; if it does not fill these conditions select another one, and try again. Another important requisite is, to have it of the proper length; to determine which you will put the fuzee, with the chain wound on it, in its place in the lower plate with the snail in the position it occupies when resting against the stop; also put the barrel in the lower plate, extend the loose end of the chain on the barrel, and when hooked, from half to three-fourths of an inch of it should rest on the barrel. If much shorter than this there is danger of breaking the hook in winding; if much longer, the chain will be liable to run over to the *upper* side instead of the lower, when the watch is running down. If, instead of putting in a new chain, it is desirable to mend the old one, or attach a new piece, observe the same conditions as for a new one. With a knife carefully open one end of the broken chain, and remove the rivet, which is best done by laying the chain on a riveting stake, or other convenient metallic substance, and holding it down with the forefinger of the left hand, the nail of the same on the extreme end link, and if the knife is sharp you can insert the edge of it between the upper and centre plates forming the link; as soon as you have loosened the outer plate, turn the chain over, and loosen the opposite plate; then remove the centre one; if the old rivet does not come away with the centre plate, you can easily get it out with the knife. Now take the other piece of the chain and lay it down the same as you did the first one, only with the finger nail on the *second* link, and remove the two extreme outer plates by inserting the edge of the knife between them and the centre plate of the *second* link; remove the old rivet, and put the two pieces of chain together, being careful to have the convex face of both pieces on the same side; make a rivet out of steel wire that will fit the holes in the links; make the rivet nearly straight, and file it up with a *fine* file; have the chain lying flat on the bench; insert the end of the wire in the hole, and give the end of the pin vice one or two slight taps with a hammer, which will force the rivet in sufficiently tight. You can lift the chain up by the rivet if it is in tight enough. Cut off the end, and file it square with a fine file, and nearly down to the chain, leaving just enough projecting so that you can perceive it with an eye-glass; cut off the other end and serve it in the same way, then lay the chain on the anvil of your vice, and carefully rivet it together with a few light blows of the hammer.

Sometimes a chain will "turn" on the bar-

rel, and persist in lying flat; some recommend reversing the chain, *i. e.*, changing ends. This method I consider a mere make-shift for the time being. We should try and discover the cause of this trouble, and then apply the proper remedy. See if the barrel is upright and true and if the arbor fits it well, and if the fuzee is also upright and its arbor fits well in the holes in the plate. If these conditions are not all fulfilled, some one or more of them may be the cause of the difficulty. Again, a very frequent cause will be found in the main-spring; it being entirely too strong, or the chain may be a very inferior one. If so, it will be very apt to act in this manner. Sometimes the chain is not thick or strong enough, or it may be too long, which will sometimes cause it to "turn." Sometimes a watch will stop occasionally, and upon examination we find the barrel spread to such an extent that the chain rubs against the pottance, or it may turn down on its flat side on this account. As the barrel in this condition becomes a truncated cone, consequently the strain on the two sides of the chain are very unequal. Now it is not an uncommon thing, by any means, to find where some one has tried to remedy the "spread" of a barrel by hammering out the lid until it fits the barrel, then bringing the Universal Lathe (or still worse—the file) into requisition to turn out the pottance.

The Universal Lathe is an invaluable tool, but it is made the means of covering the gross ignorance of some so-called watchmakers, who never seem to be at ease when repairing a watch until they can get it up in the lathe, and turn out the pottance, barrel bridge, lower plate for centre wheel, and *both upper and lower* plates for fuzee, and then, in case the watch fails to "go," attribute the cause to the man who made it, feeling, no doubt, that he had done all that any one could do for "such a watch." If these workmen would confine their art of disfiguration to common watches no one would care much; but, no, a Frodsham, Hoddel, Tobias, E. D. Johnson or other fine watches are all put through "a regular course." It is a great pity that the public generally are not competent to judge of the *quality* of watch work; but we have to take the public as we find it, and it may be for the best, as we are told by good men, that *all* things are for the best.

I am frequently astonished to see how a watch can possibly run and keep anything approximating tolerable good time, when I take it to pieces and see its condition. Not only the plates "turned out," but the pivots too small and irregular in shape, the staff looking as if it had been filed up, pivots so soft that the least thing will bend them; and sometimes I have seen a watch running and doing tolerably well—"only she stops sometimes," the owner would say—that had a pivot soft-soldered on to the staff; no hole drilled into the staff, but simply had a pivot stuck on its end with soft solder. And then to know that the "tinkers" who do such work succeed, by their blowing, in making their patrons believe them to be the best workmen in that part of the country is, to say the least, very annoying. I now have one of these chaps in my mind, who is as ignorant as a horse-block—whose father and several brothers are *watch-breakers*, and probably as ignorant as himself. One I know to be: and he frequently tells his customers that his whole family were "*born watchmakers.*" I can only say that, if they were "born so," they have certainly outgrown their natural or born condition, and at the expense of the public. If such men could only be induced to read the Horological Journal occasionally, they might become a little more modest in their pretensions.

I did intend to take up the fuzee in this article, but to do so would make it much longer than desirable. My experience and observation go to show that short articles are more generally read and do more good than long ones.

The reader will please refer to the preceding number of the Journal, and make the following corrections in article 2d on "Watch Repairing." 1st, on page 25, second column, 25th line from the bottom where I speak of obtaining a new barrel from a material dealer, the types make me say that "it is *not* an easy matter to fit a new one." Now just erase the word *not* and you will have what I intended to say.

2d. On page 36, second column, the sentence commencing at the 19th line from the bottom as it there appears has no sense to it; it should read thus: "After having selected the spring that you intend to put in, break it off full long, try it in, and if *on a radical line the space oc-*

cupied by the spring equals the open space between the spring and the arbor, *then* the spring is of the right length, provided the strength is correct."

I would be obliged, if each and every reader of this JOURNAL would take the trouble to get the August number, and make the *actual corrections* as above indicated. I am in hopes to obtain the proof in time hereafter to have the necessary corrections made before the JOURNAL goes to press—obviating the necessity of the readers making them for themselves.

Concave Lenses.

The almost universal combination of the optical with the jeweller's business, among the watchmakers in small towns, makes it proper and expedient to give that class of readers of the JOURNAL such useful hints as may come to hand with regard to every department of their business. Probably no branch of the optical department presents so many difficulties to the seller of spectacles as that of fitting those eyes properly which require concave lenses. This arises from two reasons, one of which is that the demand for such glasses is not so universal as for convex, and in consequence not as much experience and knowledge is accumulated upon the subject of myopia, and another is that there are more idiosyncrasies of structure in those eyes affected by this disease than others. Near-sightedness is, for the most part, congenital; only in exceptional instances does it occur from subsequent causes, and in that respect it essentially differs from presbyopia, which, except on rare occasions, is a gradual acquirement consequent upon the lapse of time which entails a natural deterioration of some of the peculiar organs of the eye itself; consequently malformation of the organ is not usually to be expected in those eyes where vision is defective simply from old age.

Near-sightedness, as all are aware who have given the subject even a slight investigation, is either an excess of refractive power in the lenses of the eye, or the axis of the eyeball is too long, so that the rays of light emanating from distant objects, called parallel rays, are brought to a focus *in front* of the retina, and not upon it, as they should be in order to form a distinct image; instead of which, they form circles of diversion upon it, which gives to distant objects an indistinct and blurred appearance. Persons thus afflicted will be observed to remedy this defect by means of narrowing the opening between the eyelids, and by this means prevent some of the outer circle of rays from entering the eye, which diminishes the circles of diffusion, thus causing the object to gain somewhat in distinctness of outline. It also produces a certain amount of pressure upon the eyeball, thus rendering it a little less convex, and consequently less myopic.

The action of the concave lens upon the distant or parallel rays is to render them divergent before entering the eye, an effect which is also produced by bringing the distant object itself near the eye; because those divergent rays which proceed from the distant object are not received by the eye, but which do enter it when brought near their divergence at a certain distance, being exactly compensated for by the excess of refractive power in the lenses of the eye, and, as a consequence, the image is formed *upon* the retina instead of in front of it, as is the case when seen only by means of parallel and convergent rays.

As an approximate rule for getting at the requirements of a near-sighted eye, Prof. Youmans gives the following rule: Multiply the distance in inches at which the person is able to read easily with the naked eye by the distance in inches which he wishes to read, and divide the product by the difference between the two.

Example. Four inches being the distance of distinct vision by the unaided eye; twelve inches, the distance at which it is desirable to to read, and the mean of the two distances being twelve, gives $4 \times 12 = 48 \div \frac{4+12}{2} = 6$ inches, the required focus. This will be *about* the lens required; but, as was before stated, the pecularities of myopic eyes set all rules at defiance, and the final adjustment in all cases must be by actual trial by the person who is to use them. Near-sighted eyes are not sound ones, and the peculiarities of vision which in certain respects resemble myopia, and in others do not, make it highly proper, in fact almost imperative upon the ordinary dealer, to refer all patients who are not readily suited with

concave glasses to the professional oculist for a diagnosis. Weak-sighted persons often suppose themselves near-sighted because they cannot distinctly see small objects without bringing them near the eye; and yet they are simply amplyopic; and concave glasses in such cases impair instead of improving distant vision. Again, patients may suppose themselves myopic because distant objects are imperfectly defined, when, in fact, they are suffering from hypermetropia, and require convex lenses instead of concave.

These lenses, as all are aware, are ordinarily met with in three forms: double concave, plane concave, and concave convex, or negative periscopic. In these latter the concavity exceeds the circle of convexity. There is some confusion in the method of numbering the concave lenses of different foci. The French and Germans number them as they do the convex—the higher the power the lower the number—the numbers corresponding to the focus of the convex lens which is required to neutralize the refraction; a 6-inch concave requiring a 6-inch convex to convert both, when placed upon each other, into plain glass. The English mostly use an opposite scale and give most concave glass the highest numbers. With us in this country the French method is most in use, and very properly, for the convenience it affords in determining the focus.

In the replacement of a broken glass, the focus not being known, the selection of a lens to match is often tedious and perplexing, and frequently not correctly arrived at, and in consequence the wearer is inconvenienced, if not absolutely injured thereby. The usual make-shift in such cases is to compare the appearance of a distant object through the glass to be matched, with the same object as seen through a lens, the focus of which is known, and put in a glass of corresponding number. This is an uncertain and inexact way, giving, except by an accident, only approximate results in correctness. Another mode is better, but still liable to many errors, which is by measuring by means of a focus box, the number of inches from the concave surface at which the image of objects is formed as reflected from that surface, making the lens in fact an imperfect concave mirror. This gives an indistinct image, owing to the fact that but a small part of the rays of light are reflected from the surface, a large share of them being transmitted through the lens. For short foci, this method does very well, but for concaves of long focus the feeble light reflected is dispersed over so large a surface that the image is nearly invisible unless formed in a camera, or dark chamber. This will give the correct focus for only plano-concave lenses, and such of the double concave as have *both concave surfaces ground to the same curve;* for if the curve upon the side opposite that which is measured be of another form, the true focus of the lens is not correctly indicated by reflection from the surface. This will be readily understood by studying a concave periscopic. Suppose, for instance, you measure the concave focus of such a lens, which has its convex surface ground on a circle concentric with the concave one, it will at once be seen that such a glass has *no focus,* is quite neutral, instead of being, as measurement indicates, four or six inches as the case may be.

The more exact way of determining the foci of such lenses is by neutralization, that is, applying to them a convex lens of such power as to reduce both to a plain glass—that objects seen through both when placed together, shall have their natural appearance, shall suffer no distortion. The true focus of *any* concave lens, will be the focus of such a convex one as will exactly neutralize its refraction. And by having a set of convex lenses set for trial, the foci of which are known and marked, the concaves are easily measured; or, by having a set of concaves that are correctly marked, the focus of an odd glass is easily determined with almost mathematical precision by placing the unknown focus above or below a known one in the same vertical plane, and observing, through them, any parallel vertical lines at a little distance away, as a narrow up and down stripe on wall paper, or two up and down sash bars, or even the two edges of a floor-board, and noticing whether each lens diminishes the width of the space between the two lines equally; if they do, the lines as seen through each lens will be continuous; if, on the contrary, one is more concave than the other, the lines as seen through them will not coincide, and the known focus must be changed till one is found, which makes them coincident. This method is very convenient in practice as

the exact correspondence of two lenses in focus can be detected in a moment, and that without any instrument except the ordinary surroundings at the moment.

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Reminiscences of an Apprentice.

A CHAPTER OF ACCIDENTS—MY LADY'S WATCH—OUR MINISTER'S CLOCK.

I hope that it will not be considered as traducing the memory of that most excellent man, "Our Maister," if I tell a little secret concerning one of his personal habits. All men have their little weaknesses, and the very best of men will indulge in little habits of self-gratification; the peculiar weakness of "Our Maister" was a custom he had of using snuff. I do not know why he contracted the habit unless it was for the benefit of his eyes, which were always weak; but although he indulged in this practice there was nothing in his personal appearance which betrayed that he was addicted to the custom, and it was only those who were in close business or social relations with him that knew any thing about it.

One day I was making the rack and snail motion for the striking part of an eight-day clock. It was the first one that I had made all through without any supervision, and, thinking that I had done very well, I took it to the "Maister" to be examined; but, as usual, he had some fault to find. The teeth in the rack were well cut, and were just the shape to suit him; the tumbler, or gathering pallet, was exactly the shape that he wanted it to be, and it worked into the rack to please him; the warning part was right, too, and he had no fault to find with the equality of the divisions in the snail; but the work, as a whole, did not please him. He said that if ever the clock was allowed to run down, and the striking part to stop before the time part, that the clock, when it was wound up again, would continue to strike on without stopping till the weight ran down a second time. I suggested that, in the frame of clocks which I had cleaned, I had seen a guard pin put in to prevent the teeth of the rack from ever getting beyond the reach of the tumbler; but "Our Maister" would have no guard pin put into his clocks for this purpose, which, he maintained, was an unworkmanlike manner of correcting an error that had no business to exist; and that if a rack and snail motion was properly constructed it required no guard pin, nor could it ever get out of order under any combination of circumstances. He then took a pretty good sized pinch of snuff, and was studying out the easiest way for me to correct my botched work, when the carriage of one of the aristocratic families in the neighborhood drove up to the door, and our old friend the half-pay officer and a lady alighted. The lady was one of the very finest, and could not come to our town to do business with any of the tradesmen without an escort of some one connected with the nobility, however remote that connection might be. The lady desired to have her watch examined, which had been going very irregular previously. It was the prettiest little watch which, at that time, I had ever seen, and "Our Maister" took it and looked over it, but not seeing any thing wrong, he sat down at his bench, put on his eye-glass, and for a minute or two was earnestly engaged examining the watch, when a large drop of water and snuff imperceptibly collected on the tip of his nose, and, before he was aware, it fell right in between the frames of the watch. Now here was a nice fix for the "Maister" to get into, with such a nice watch and so fine a lady, too; and I must confess that I felt an inward satisfaction at the occurrence, for, at the time, I was angry with him for finding fault with my work, and I eagerly watched to see how he was going to get out of the scrape, and how he would act under the circumstances; but, with that candor and decision of character that was so characteristic of the man, he rose up and told the people just exactly what had happened. I need hardly add that the watch was cleaned and put in perfect order without losing a moment's time, and after being tried for a few days and regulated, it was returned to its owner, who expressed herself pleased at the happy termination of the accident.

This occurrence was the means of postponing the lesson I was to receive in making the rack and snail motion of the striking part of a clock; and one Sabbath morning, shortly after, there was a great commotion took place at our minister's house. The minister himself had

gone from home the day previous, and, contrary to his usual custom, had neglected to wind the clock before leaving, and on Sabbath morning his housekeeper, not hearing the clock strike, concluded that it required winding, and took the key from the top of the head and wound up both weights; but she had no sooner done this than the clock, in order to make amends for its late silence, or for some other reason, commenced to strike on continually, thereby seriously interfering with the usual quiet and decorum of that secluded neighborhood. All the shaking, or hugging, or entreating, the poor woman could do would not make the clock resume its usual respectable behavior, and she came running over to our house to see what I could do towards making the erratic clock keep quiet, and restore peace to the neighborhood. Of course I went over, but the head of the clock case was barred from the inside, the door of the case was locked, and the minister had the key on his ring; consequently I could do nothing because I could not get into the inside. The hammer in the meantime continued to clang, clang, against the bell incessantly, while the face of the clock seemed to look at us defiantly, and the usual quiet and decorum of the Sabbath morning continued to be seriously disturbed. A number of the neighbors collected in the hallway of the minister's house to stare at the lunatic clock, and, although the minister himself had commenced to dance a jig in the pulpit, it would not have created greater consternation than the change that had come over the usual staid and sober old clock, which was the very personification of regularity and gravity.

But something had to be done; and, as is usual on such occasions, there was no lack of advice. One proposed to pour water on the clock, and in that way disable it, and make it stop striking; another thought that to burn paper underneath the clock would burn the cords the weights were suspended from, and in that manner restore silence in the house; while another thought that laying the clock on its back might perhaps soothe it and make it peaceable again; but, although this proposal was a reasonable one, nothing short of an earthquake could put it into practice, because the strong heavy case of the clock was firmly bolted to a stone wall. One unthinking individual, forgetting the sanctity of the morning, tried to perpetrate a joke on this being a very strong and *striking* example of the evil consequences that may result from doing any work on the Sabbath day. This attempt "to improve the occasion" was speedily put down, as it deserved to be, and, putting them altogether, these wiseacres made a greater disturbance than the clock, although it did its best to keep the lead in the noisy clamor. At this juncture "Our Maister" appeared on the scene of noise and gossip, and asked why I had not stopped the striking of the clock; and I told him that everything was locked up and I could not get into it, when, without saying a word, he took the end of his walking stick and knocked in a sounding board on one side of the case, and putting his hand in the hole he tried to reach the rack and push it into action with the tumbler again. The hole was too small, and he could not reach the rack, but he managed, with the aid of his walking stick, to stop the pendulum. He then opened the door at the front of the dial and set the minute hand to about two minutes or so from the hour, which placed the mechanism of the clock in the warning position, and stopped all motion of the striking part, when, as a consequence, quiet was immediately restored in the clock, and in this disabled condition it was allowed to stand, till Monday morning, in order that it might reflect on the impropriety of its late conduct, and form resolutions for a better behavior in the future.

The following day "Our Maister" took me along with him to the minister's house, when we picked the lock of the clock case and corrected the clock, causing it to strike the hours and tell the time as usual. On coming home "Our Maister" took special pains to impress on my mind that I was the cause of all the disturbance of the previous morning; that I had neglected to follow out his instructions when putting new cords on the clock a few weeks previous; that I had left the striking cord shorter than the other one, and when the clock was neglected to be wound at the usual time, the first time twelve o'clock passed, the rack not being gathered up by the usual striking of the hours, its arm rode over the snail, and finally the rack-spring pushed the teeth of the rack out of reach of the tumbler, and the first time

the clock was wound up afterwards there was nothing to stop the motion of the striking part till the weight had run down a second time. I did not like to be blamed for all the disturbance of the previous morning, and thought it unjust, and ventured to tell the "Maister" that a short time ago he told me if a rack and snail motion was correctly made it could never get out of order under any combination of circumstances. "Yes," he answered, "that is just the point I wish to speak to you about. There is no necessity for these clocks ever going wrong in the striking. Yet, although it may be so easily prevented, very few take the precaution to avoid accidents of this kind. Simply leaving a few more teeth in the rack than is necessary to strike the hours, or making the snail of such a size that the twelfth step will be near the socket of the wheel it is carried on, will make a clock safe against all troubles of this kind. I knew, however, that this clock was not made with that precaution, therefore I warned you to leave the new cords of such a length that the clock would always stop going before it stopped striking; but you, not attending to my warning, and the minister neglecting to wind the clock, produced all the commotion of yesterday morning." I was quite willing to stand any amount of blame if the minister was in the fault along with me, and so allowed the further discussion of the subject to drop on that occasion.

Clocks and watches, like individuals, have mostly all some weak point in their composition, which sometimes causes those apparently the best and most regular to go temporarily astray and perform the most eccentric kind of actions. However, clocks and watches, like individuals, may be guided and humored, although I admit that some subjects are more difficult to manage than others. After this occurrence with the minister's clock, at any time when I had to make the rack and snail motion for the striking part of a clock, I always took the precaution to construct it so that the rack would never get into such a position as to be out of reach of the tumbler or gathering pallet. When putting new cords to a clock of this kind I never forgot, nor do I yet forget, to leave the striking cord a little the longest of the two when I am not fully aware of the exact manner in which the rack and snail motion is constructed.

Alloys and Solders.

M. Guetlier, in his work on Metallic Alloys, gives these directions for melting.

1*st.* Heat the crucible to a red and sometimes a white heat, and melt in it the least fusible component of the alloy. After fusion increase the heat somewhat, so that it will bear the addition of the next fusible one without too much reduction of temperature.

2*d.* Introduce the metals into the pot in the strict order of their fusibility, each being fully melted before the next is added.

3*d.* When some of the components are fusible and some refractory, the alloy should be covered with charcoal, or if rich in tin it must be covered with a layer of sand.

4*th.* Stir thoroughly before casting, and if possible, while pouring, with a white wood stick.

5*th.* Always add a small portion of old alloy to the new, if at hand, and in all cases use clean crucibles.

Plastic Metallic Alloy.

This alloy or amalgam adheres to glass or porcelain, uniting them firmly in 10 or 12 hours. In preparing this alloy, finely divided copper is produced by reducing the sulphate by metallic zinc. Of this copper powder take 20, 30, 36 parts, according to the hardness required. Moisten this with sulphuric acid Sp. gr. 1.85 in a porcelain or cast-iron mortar. To this paste add 70 parts of mercury by weight, the mass being kept agitated or stirred. When completely amalgamated, the composition must be washed in hot water to remove all trace of acid, then be left to cool. In 10 or 12 hours it will become hard enough to scratch tin. When required to be used, it can be rendered plastic by a temperature of 375° C., working it in an iron mortar until it is as ductile as wax. If in this state it is placed between two surfaces free from oxidation, it will unite them perfectly; it is especially useful as solder, in such places as preclude the use of heat for that purpose.

Metallic Alloy for the Formation of Small Figures.

Which melts at low temperature and when moulded, possesses considerable hardness, and is not brittle.

Bismuth	6
Zinc	3
Lead	13

They are first melted in a crucible or ladle, poured out, and then remelted. It takes the mould with great sharpness, and if the figures produced are bitten in by dilute nitric acid, washed with water, and polished with a woollen rag, the elevated portion becomes bright and the depressions a dark gray antique lustre. In 100 parts there are

Bismuth	27.27.
Lead	59.09.
Tin	13.04.

Alloy for Small Casts.

Bismuth	6
Tin	3
Lead	13

The metals are melted in an iron ladle, and cast into ingots, and re-melted before used.

Bismuth	3
Tin	1
Lead	1

Is harder without being brittle or presenting a crystalline fracture. If the casts are wet with dilute nitric acid, then rinsed in water and rubbed with a woollen rag, the prominent parts become bright, and the cavities have the dark gray color of antiques; it takes the finest lines perfectly.

Hard Solder for Gold.

Gold 18 k. $\frac{750}{1000}$ fine	18
Silver	10
Pure copper	10

Hard Solder for Silver.

Silver	66
Copper	23
Zinc	16

Solder for Platinum.

Pure gold with $\frac{1}{2}$ per cent. of alloy of platinum and irridium.

Hard Solder for Aluminum Bronze.

Gold	88.88
Silver	.4.68
Copper	6.44

Medalling Hard Solder for Aluminum Bronze.

Gold	54.04
Silver	27.
Copper	18.06

White Brass.

This metallic alloy may be turned, filed, or bored, and when cast does not adhere to moulds, and retains its lustre for a long time in the open air.

Cast iron	10
Copper	10
Zinc	80

Solder for Iron and Brass,

said to have the same expansibility as brass.

Tin	3
Copper	39½
Zinc	7½

German Silver Solder.

German silver	5
Zinc	4

Alloy for Obtaining Casts of Medals & Coins.

Kaft's alloy melts at 104 C.

Bismuth	5
Lead	2
Tin	1

Homberg's alloy fusible at 122 C.

Bismuth	3
Lead	3
Tin	3

Rose's alloy melts at 93 C.

Bismuth	2
Lead	2
Tin	2

Amalgam for Varnishing Plastic Casts.

Tin	1
Mercury	1
Bismuth	1

The mercury is added to the tin and bismuth (melted), and stirred into combination, pounded with the white of an egg, and forms a liquid mass, applied with a brush.

Cement to Fasten Rubber to Wood or Metal.

Make a cement by soaking pulverized shellac in ten times its weight of strong ammonia; this gives a stringy mass, which in three or four days will become liquid without the aid of hot water. This cement softens the rubber, which, after the volatilization of the ammonia, becomes hard and impenetrable to gas or liquids.

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Friction.

ED. HOROLOGICAL JOURNAL:

I now advise you to have the word Friction stereotyped as a permanent heading for your columns.

The interest which has been expressed on this subject convinces me more than anything else that this is not an exact science. If I supposed that I was the only one of your readers who holds such peculiar opinions on this subject, I would say to you candidly that your valuable columns might be filled to better advantage; and to your correspondents, my opinion (which no doubt agrees with their own), that their time might be better employed. The per-

sistency of your correspondents assure me that they think there are many who are, perhaps, opposed to their theories, or who are, at least, in doubt concerning them.

The analysis of my experiment in friction by "Clyde" did not do it justice. He confesses that he did not understand part of it. The motive which he assigns for the second part was as far from the true one as the poles are apart. I will, however, take the blame upon myself. I should have entitled the article "Experiments," for there were three of them. The one thing I cannot comprehend is, that the "generosity," or ideas of generosity of any one, no matter how able or how insignificant, has anything to do with an argument in mechanics. On the contrary, it appears to me that any allusions of such a character, whether in good faith or sarcasm, are rather out of place in this discussion. My reason for using Babbitt metal was simply because I could attain my object easier than with brass. I made the hole in it in the usual manner, by casting it in a box with the mandrel in its place, and afterwards working it till it fitted easily; the object being to compare the three experiments. I thought, and still contend, that it was a very fair way of testing the matter.

The almost impossible and ideal perfection which Clyde seems to think that I claimed for the model, I repudiate. I intended to convey the idea that my lathe is one of the best, and superior to most of the philosophical models that I have seen, and the allusions to my language in this respect were mere quibbles. By selecting a tool familiar to all watchmakers, I hoped to appeal to their judgment in the quality of the workmanship, and the fairness of the test.

The objection which Clyde urges as fatal to the experiment, in case the force was not applied in the direction of the centre of motion, is more seeming than real. Although the hole in the tailstock was $2\frac{3}{8}$ inches, the mandrel was much longer. I did not feel rich enough to sacrifice my lathe in order to conduct the experiment in a particular manner. I carefully balanced the mandrel, pulley and weight; but even if the pressure was down on one end and up on the other, it was equally so in all the experiments, so that the conditions remained the same. In order to test this objection thoroughly, I have since then applied a pulley to each end of the mandrel, and divided the weight between the two, and I have not observed any material difference between this and the former experiments.

There is certainly a difference of opinion between Clyde and myself as to whether the surface of the holes was good enough for a fair test. He thinks it was not, because the results of the experiments were not of the nature he anticipated. I thought the surface was good enough, and made up my mind that the results would indicate the truth, before I tried it, and when I was very anxious and perhaps doubtful (after all that has been written on the other side) about the results. That I am not wrong in guessing the basis of Clyde's opinion in this respect, I refer the reader to his extravagant claim that the results of a more perfect experiment, and which he declares almost impossible to execute, will be likely to carry out his views. I know very well that every particle of the bearings and mandrel did not touch each other, and of course made no claim to such a state of things. I am willing to abide by Clyde's admission that they probably fitted without shake, and did not perceptibly bind. Even under these circumstances the surfaces in contact in the first experiment were enormously greater than in the third.

If the careful reader will make every allowance for the quality and kind of metal, temperatures (of which there was no change), etc., he will, I think, still find a large balance in his calculations which can be allowed only to the differences in friction.

The authorities cited seem to be mostly in regard to flat surfaces, and if I could see no difference between the friction of such surfaces and that of pivots in their holes, I should consider the subject of no great importance. Clyde's second proposition tends this way, but he immediately refutes it by interposing an objection of his own.

On another point—a question of fact, not of opinion—I join issue with Clyde. In this respect he is mistaken. *Parker's Philosophy*, 1859, pages 98 and 99, does most explicitly deny the theory, that friction is *not* increased or decreased by increasing or decreasing the surfaces in contact. I have quoted already, *verbatim*, Parker's very clear statement in this case,

and I assure your readers, after a careful study of his work, that I know of nothing in it that in any way modifies the letter or the spirit of my quotation. In a preface to his book, Parker admits his obligations to nearly every work which has been referred to on both sides in this discussion; and yet, after having made extracts from, and consulted all these works (many of which I am, unfortunately, unable to reach), Parker concludes "that friction increases as the extent of the surfaces in contact are increased;" and that "friction may be diminished by lessening the surface of homogeneous bodies in contact with each other." Also see page 81. "There are two ways in which the wheel and axle is supported, namely: first on pivots projecting into the extremities of the axle, and secondly, with the extremities of the axle resting on gudgeons. As by the former a less extensive area is subjected to friction, it is in many cases to be preferred."

I am not a "bold man" myself—in fact, quite the contrary—but the editors of the *Scientific American* must be bold men. Within a year, an editorial in that paper stated that upon some points Moran's experiments were not satisfactory, and that they had not been carried far enough. In order to have something really practical, I would ask Clyde to describe the model in the Cooper Union which illustrates the friction upon long and short pivots, and upon their ends, and the results of a trial of this model; also the same thing in Moran's experiments with the results; and, finally, if not asking too much, to analyze Reid's statement, that the balance will vibrate twice as long in one position as the other; that in his opinion they could be made to vibrate the same in either position, and that, also, in his opinion Ernshaw's *shallow holes* and *flat* pivot ends should come very near that object.

I will take this opportunity to notice one or two points in Mr. Gribi's article, in the June No. I knew very well that there was something wrong in the first brick experiment, and therefore was not surprised when he admitted such to be the case. I imagine that neither he nor Clyde appreciates the full force of the admission. If the "thin pine board bent a little more under the pressure of all the bricks on the edge of one, than when they were distributed on their flat sides over a greater area of the board," I cannot see how their surface could touch the board, unless the bricks bent also. And yet Clyde thinks that this was a fair trial, but that my experiment was not.

I dislike exceedingly to notice personal allusions. It seems hardly necessary to remind your readers that they prove nothing. Mr. Gribi seems particularly moved by a statement of mine to which he gives prominence by substituting italics, thereby leading a casual reader to suppose that I laid more stress upon it than upon other parts of the context. At the time I made the assertion there was no work on philosophy within my reach that made the statement at first alluded to; and now that I have found it, I do not believe it. If there is one thing I like to do more than another, it is to read. But I had made up my mind, even before last November, that it was useless trying to believe everything I happened to read, just because it was printed in a book or paper. I hope, for Mr. G.'s sake, that he has since then come to the same conclusion. If I supposed that my talents or words were a fair subject for criticism, I should be much more careful how I expressed myself. I could not have attacked either Mr. Gribi or his principles, as I entered the discussion before him, and at that time had good reason for believing that I was but an humble follower in his doctrines of friction.

In making those few experiments on watches, I confess that I do think it likely that I may have cut away parts of the pivots that never touched the jewels at all. I also think it just about as likely that, in the case of the chronometer mentioned on page 135, vol. iii., that the jewels were ground away where they did not touch the pivots.

I think it strange that so little has been heard from "*Horologist*" in this matter. I like his writings, and if I am misled in my views, he certainly had a share in misleading me. I would beg him to favor your readers with, at least, a partial account of the experience and authorities which impressed him with the opinions I still hold to. If there is any advantage in theory combined with practice, his experience ought to settle it. I am sure such an able writer is an able workman, therefore I would like to ask him, for the benefit of us all, if his manner of adjusting watches,

before "he saw the error of his ways," was altogether wrong where he obtained such good results; and if not wrong, were they adjusted according to his expressed principles which he now regards as false theory. I wish to point out to your readers, that if "*Horologist*," working upon a certain theory, can properly adjust a watch to position, and Mr. Gribi, who I am certain is also an able workman, can do the same thing, working upon directly opposite principles, then it matters very little whether either or which of them is right, and that the subject of friction in this respect has attained a prominence to which it is not entitled.

B. F. H.

Sag Harbor.

Long and Short Screw-Drivers.

Ed. Horological Journal:

In the last number of the Horological Journal, E. H., of Hartford, Conn., wishes to know "why a long screw-driver has more power than a short one," and says, "he can see nothing that explains this strange fact in any work on natural philosophy." His screw-drivers have handles of the same length and diameter, the points are alike, but the point of one is one and a half inches from the handle, the other four inches.

Your reply does not appear to fully answer the question, and as you are willing to receive any other solution that may be given, I submit the following one:

The screw-driver may be said to represent one of the three ways in which the lever can be used, wherein the fulcrum is between the weight or resistance and the power.

In using the large screw-driver of which E. H. makes mention, the hand reaches down farther, the handle comes in contact with more muscular surface, and consequently more power can be exerted upon the screw. This increase of power is illustrated in the turning of a button or a top, that can be whirled more rapidly with a long pin than with a short one.

That power only can be transmitted which is produced, minus the friction of machinery and the resistance of the air.

A little research with the aid of science transforms the "strange facts" found in mechanics into simple truth, and when we turn from inquiries similar to the one your correspondent has made, and attempt to solve the more difficult problems connected with the highest branches of Horological Art, your Journal becomes a valuable medium for the dissemination of useful knowledge.

A. W. Gorgas.

Hudson City, N. J.

Mechanical Science.

Ed. Horological Journal:

Is there any treatise published upon the subject of mathematical mechanics that gives such instruction as practical mechanics require, and no more? I mean arithmetical, geometric, and possibly algebraic; for I must confess myself so ignorant as not to know whether algebra is essential to the education of the practical mechanic. I know plenty of works that treat on these subjects separately and so profoundly that they intimidate by their formidable appearance, and by the fact that in glancing through them the ordinary mechanic sees no *practical* use for the philosophy there taught; and yet he knows enough to know that there are within it *concealed* valuable facts which those of his profession who are fully educated can apply in its practice. Then, again, there are other works that give a smattering of all science, which is equally inapplicable to practical purposes. What I should like,—and I know many others who are equally anxious,—is some work that will give me what of science is really necessary; a work in which the useful is selected out from the theoretical, or in which the theoretical is applied to the practical by illustration and example in every-day operations; in other words, the rudimental works on such subjects only give principles, and the complete treatises go to such profound depths that a laboring man has not time to master them even if he has the inclination. In geometry and mathematics we wish to be taught what a mechanic ordinarily requires to know, and the correct method of applying that knowledge to the various mechanic arts, and we should like to avoid spending precious time in learning such things as in our ignorance we imagine to be necessary, only to find out at last that they are not needed, or that we still lack the proper knowledge to apply

them in practice. Now there must be, or if there is not there ought to be, some work so arranged and classified by an educated, thoroughly practical mechanic, that it shall be adapted to the want I have described. It ought to give simple practical illustrations, and the application of the principles taught to the various mechanical operations; in a word, it ought to be, on the one hand, not a superficial instructor, nor, on the other, too abstruse, but have the absolutely essential culled out of the whole and put in a form adaptable by those who wish to become intelligent mechanics, and who have not time to be wholly scientific.

I suspect such a compilation a difficult thing to do, or we should have plenty of books of that sort. It might be necessary to give to each of the various mechanical operations its especial treatise. The tailor would not probably require much of algebra, and yet there are principles in some departments of mathematics that he would need to qualify him for a master in his business. The cook would not need to spend his time in the study of geometry, but there are principles all through chemical science eminently adapted to make him an expert in his art. The architect would require but a short chapter upon geology, but geometry and its sister sciences would be absolutely essential to success in his art. Such an epitome of all that was necessary to each profession would not oblige an artisan to wade imperfectly through the whole circle of the sciences to find a few applications to his own special wants.

It has sometimes seemed to me that the wonderful facilities for education in these modern times have had an effect quite contrary to the general supposition; and that, instead of knowing more, mechanics know less really than heretofore; in attempting to grasp all, nearly all is lost. A jug cannot be filled by a deluge of water poured over it; the little goes in, the much is wasted. The fashionable necessity for being educated—the disgrace (almost) of not knowing something about every thing—has made it indispensable that every child, as soon as A B C is acquired, shall take a place under an educational funnel, and have poured into its open mouth a deluge of knowledge, the major part of which will subsequently be of not the slightest practical use, even if remembered, which is doubtful. In the overflow and consequent loss by this cramming process, much that would have been useful is irrecoverably lost, and much that is retained is almost useless. This method of teaching has compelled book-makers to compress science into the smallest possible compass, as bales of cotton are pressed for shipment, and consequently its beauty and usefulness are as effectually concealed from the recipient as are the snowy flocculent beauties of native cotton within the impenetrable parallelogram of stuff the hydraulic press makes of it. Cannot we mechanics make some "strike" against this system of popular education,—some combination that shall give us a chance to get a little more actual knowledge with a little less study?

Pardon me, dear JOURNAL, for allowing the train to run down in the way I have; the fact is, that as soon as I get the escapement out I can't "stop her" till the spring is all uncoiled. What I started out to say was, that I know there are thousands of intelligent watchmakers that would gladly buy a book that would give them, in a practical form, all the scientific knowledge that is applicable to our art, divested wholly of science, *as such*. And if there is none ready made, can you not induce some scientific watchmaker to issue such a work? There is surely somebody in the world capable, and if a beginning was once made it seems to me that the benefits of such a compilation would be so apparent that every profession would soon have its scientific text-book, which would be as essential and peculiar as the tools with which each particular artisan wrought.

CYCLOID.

Boston, Mass.

The want which "Cycloid" expresses as being felt, is a plant of as recent growth as the cramming system of education of which he complains. Until very recently there has not been a thousand watchmakers in the whole world who cared a pin for the *science* of the art, and the author or publisher who ventured to issue a scientific treatise on the subject would have had only his losses for his profit. If any one could publish a method by which two dollars could be made out of one honestly (or otherwise), purchasers would be numerous. The tradesman or mechanic who can get the most money for the least work gets rich fastest, and his "method" is copied, if it can be found out,

by all aspirants for a like position. Happily, this state of things is slowly passing away, and talent among mechanics is beginning to be appreciated. If "Trades Unions" do not become a power in the land, we hope to see the day when a skilful workman can maintain the dignity of his profession and be adequately paid for his labor in exact proportion to his skill, without the aid of a horde of slipshod and ragged helpers. When that day arrives science will come in for her share of the honor and the profit.

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A Standard Ring Scale.

Ed. Horological Journal:

I have lately made a ring scale which I find more useful than the old style. Perhaps a notice of it may lead some makers, like Brown & Sharpe, to make a scale that will meet with general approval.

The scale is made of flat sheet brass, thick enough to be durable, 5 inches long, 1 inch wide at one end, ½ inch at the other. One flat side is divided into 25 sizes, each 2-10 inch apart. These sizes are subdivided into halves, and may be into quarters. Therefore each size of ring will vary in diameter, only 2-100 of an inch, and half sizes only 1-100. The sizes are numbered from 1 to 25; also, on the outer edges, in decimal parts of an inch. The circumference is calculated for each size and laid out on the reverse side. Any jeweller can make one in a short time. In calculating the circumference, multiply the diameter in decimals by 3.14. This will give the inside size of the ring. In cutting a strip to make a ring, the outside should be the thickness of the metal longer than the inside. If it is made for sale and generally adopted, it will prove a great convenience to the trade. Its merit consists in its forming no arbitrary standard, as the measurements are all in common use. So that even now if I should order a ring .77 diameter I should be very likely to get it, as the dealer would know exactly what I wanted. If the ring is not quite round the size can be taken better than by a round stick, by trying the scale in two directions and averaging them. It will take the exact size of a seal ring by applying it to the cross section of the shank. It will also be useful in measuring holes of other kinds within its limit. B. F. H.

Sag Harbor.

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Answers to Correspondents.

J. N., *Ingersol, Canada West.*—The annoyance of which you complain appears to be inseparably connected, not only with our business, but also with all businesses which receive their support from customers so varied in their characters and dispositions. To a young man like yourself, newly started in business, aiming to do his work in a thorough manner and at a moderate price, it is exceedingly vexatious to be blamed, as you have been; but you are not alone in this respect; instances of this kind occur frequently in all parts of the country—in large cities as well as small towns. A case came under our observation a short time ago, which, although of not such an aggravated character as the one you describe, is somewhat similar. One hot evening in the middle of summer, while passing along one of the leading avenues in the city, we dropped into the store of Mr. Spitzka, an experienced and skilful workman, in order to rest a few minutes and enjoy a horological conversation. Our talk was interrupted occasionally by customers calling on business, and once, a middle-aged individual, carrying something wrapped up in a white towel, came into the store and placed his bundle on a chair that stood convenient in the middle of the floor. The newcomer's appearance indicated, and his speech betrayed him to be "an exile of Erin," and it was evident from his anxious looks that some trouble weighed on his mind more than the wrongs of his country. The bundle he carried, on being opened, proved to contain an old thirty-hour weight Yankee clock, which he said had been cleaned at that shop in the month of April last; he paid a dollar to get it done, and the clock was warranted at that time to run for twelve months. Mr. Spitzka answered him good-naturedly, and proceeded to open the clock to see what was the matter, and on the dial being removed a lively scene presented itself, for the inside literally swarmed with cockroaches, and some of them had got caught by the treacherous motion of the wheels

and were crushed between the leaves of the pinions, and stopped the clock. Our Hibernian friend protested his innocence of all knowledge of the cockroaches using his clock as a habitation, and could not account for the fact of their being there. On seeing the true state of affairs, the proprietor of the store ordered the clock to be removed from that part of his premises and taken to the back yard, and that he would see to the cleaning of it in the morning. The customer could not be made to understand why the clock needed cleaning, seeing that it was done so recently, and, suspecting that there would be a demand made upon him for the price of cleaning the clock the second time, he reminded the watchmaker that he had warranted his work for a year. Mr. Spitzka did not consider cockroaches were included in his warranty, and claimed a second dollar if he cleaned the clock a second time. To this the Hibernian objected, and remarked that a man was no man unless he respected his bargain, and if he had to pay a dollar he would pay it to some other person, for no more of his money would ever again tickle the palm of that watchmaker's hand.

Mr. Spitzka, although courteous and respectful to his unreasonable customer, did not object to his taking the clock somewhere else, and after he had been gone for a few minutes he returned a second time and offered fifty cents to get his clock made right; but the watchmaker did not consider that a fair recompense for killing cockroaches, although he was getting an order to do such a large quantity, and he refused the offer. The Hibernian never appeared to think that he was violating the rules of propriety in bringing a clock in that condition into a respectable store; and finally he left, thinking himself an ill-used individual, but consoled himself with the revenge he would have on the watchmaker, and the damage that he would do his business by causing his sons and daughters to go somewhere else to get their watches and jewelry repaired, where they would be honestly dealt with.

H., *New York City.*—A query similar to yours was answered on page 48, second volume of the JOURNAL, but we answer you more explicitly than was done on that occasion. If you wish to make a new pendulum rod for a clock, to supply the place of one that has been lost, and if you know the number of teeth that are in the wheels and leaves that are in the pinions of the clock, you must first find out how many vibrations the desired pendulum is required to make in a minute to suit the number of teeth in the wheels and leaves in the pinions. This you can easily accomplish by finding out the number of turns and fractional parts of a turn the scape-wheel makes for one revolution of the wheel that carries the minute hand. Divide the number by 60, and the product will be the turns or fractional parts of a turn the scape-wheel will make in a minute. Then multiply this quantity by *twice* the number of teeth that are in the scape-wheel, and the number obtained will be the number of vibrations the desired pendulum will have to make in a minute. You must now divide the number 1,411,200 by the square of the *square* of the number of vibrations the pendulum is required to make in a minute, and the product will be the length of the pendulum in inches. To explain everything connected with this question would occupy more space than we can at present devote to the subject. We now have given you all the information necessary for any practical purpose, and in some future number of the present volume we intend to make this question the subject of a comprehensive and exhaustive article.

A. M., *St. Louis.*—It would be no easy task, and probably it would be impossible to ascertain with any degree of accuracy, the entire production of plated silver ware in the country, or even that of spoons and forks alone. We only know that there are a large number of manufacturers, and that some of them have not been able to keep up with their orders. Rogers & Bro. have this season added a 200-horse power Corliss engine to their already extensive water-power at Waterbury, to meet the constantly increasing demand upon them.

We fail to see "that the almost universal use of plated ware instead of solid silver, is another evidence of the growing tendency of the age to substitute the shadow for the substance." For all practical purposes a well plated spoon or fork, or any other article for daily use, is equally as good as the same article in sterling silver, while the cost is but trifling in comparison. In fact the interest of the money on the cost of the latter would almost keep one supplied for a lifetime with ware of equal beauty of design and

finish, and with the additional advantage of frequent changes, as still more and more beautiful designs are produced. All risk of being cheated in quality can be obviated by purchasing of well-known dealers. Few branches of industry have made more rapid strides during the past ten years than this, and still fewer that have done more to educate the public taste for a love of the beautiful in the articles of daily use.

H. E. W., *Richfield Springs.*—Acids, directly, are not used for the manufacture of Etruscan gold. Your wish, probably, is to know how to color gold, as in Etruscan jewelry. Various chemicals are used, each manufacturer having a formula of his own, which he thinks superior to that of his neighbor. In the 2d volume of the JOURNAL mention is made of the process, or the following may serve your purposes:

2½ oz. crocus, 2 oz. yellow ocre, 1½ oz. verdigris, 1½ oz. copperas, ½ oz. white vitriol, ¼ oz. Borax. All to be reduced to impalpable powder in a mortar, and mixed intimately with 5 oz. yellow beeswax, or 20 dwts. saltpetre, 20 dwts. common salt, 2½ dwts. copperas, 2½ dwts. white vitriol, 2½ dwts. alum. The ingredients to be put in an old crucible and set over the fire, and the articles to be colored boiled in it until, on trial, they are found to have acquired the desired color. The beautiful satin finish is given to the class of goods called Roman gold, by carefully scratching the dead gold surface with a scratch brush made from spun glass.

H., *Phœnix, N. Y.*—Much has been said in previous numbers of the JOURNAL on the subject of refining gold and silver. The process has been often described, and yet new inquirers are constantly asking, "how to do it." For you, except you wish to experiment for the pleasure of it, the most economical way by half, is to send your scraps at once to a professional refiner, who will, for a trifling charge, return you the silver and gold pure. On a small scale it is not possible to do it except at a pecuniary loss.

AMERICAN HOROLOGICAL JOURNAL,

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For October, 1872.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be Subtracted from Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Tuesday	1	64.38	10 29.76	0.787	12 42 5.90
Wednesday	2	64.43	10 48.48	0.774	12 46 2.45
Thursday	3	64.48	11 6.88	0.760	12 49 59.00
Friday	4	64.53	11 24.95	0.745	12 53 55.56
Saturday	5	64.59	11 42 66	0.730	12 57 52.11
Sunday	6	64 65	12 0.00	0.714	13 1 48.66
Monday	7	64.70	12 16.96	0.698	13 5 45.22
Tuesday	8	64.77	12 33.50	0 681	13 9 41.77
Wednesday	9	64.84	12 49.62	0.663	13 13 38.32
Thursday	10	64 91	13 5.31	0.643	13 17 34.88
Friday	11	64 98	13 20.52	0 623	13 21 31.43
Saturday	12	65.05	13 35.24	0.602	13 25 27.98
Sunday	13	65.13	13 49.48	0 582	13 29 24.54
Monday	14	65.21	14 3.20	0.560	13 33 21.09
Tuesday	15	65.29	14 16.37	0.537	13 37 17.65
Wednesday	16	65 38	14 28.96	0.513	13 41 14.20
Thursday	17	65.47	14 40.98	0.489	13 45 10.75
Friday	18	65 56	14 52.40	0.462	13 49 7.31
Saturday	19	65 65	15 3.19	0.435	13 53 3.86
Sunday	20	65.74	15 13.34	0.407	13 57 0.42
Monday	21	65.84	15 22.82	0.379	14 0 56.97
Tuesday	22	65.94	15 31.62	0.350	14 4 53.52
Wednesday	23	66.04	15 39.71	0.321	14 8 50.08
Thursday	24	66.14	15 47.08	0.291	14 12 46.63
Friday	25	66.25	15 53.73	0.262	14 16 43.19
Saturday	26	66.35	15 59.64	0.230	14 20 39.74
Sunday	27	66 46	16 4.79	0.198	14 24 36.30
Monday	28	66.57	16 9.16	0.166	14 28 32.85
Tuesday	29	66.68	16 12.77	0.133	14 32 29.41
Wednesday	30	66.79	16 15.60	0.100	14 36 25.96
Thursday	31	66.91	16 17.64	0 067	14 40 22.52

Mean time of the Semidiameter passing may be found by subtracting 0.18s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
●	New Moon	2 3 30.7
☽	First Quarter	9 9 3.9
☺	Full Moon	16 3 34.7
☾	Last Quarter	23 20 53.7
●	New Moon	31 17 28.2

		D. H.
☾	Perigee	12 7.4
☾	Apogee	24 8.9

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D. H. M. S.	° ′ ″	H. M.
Venus	1 13 49 57.57	−10 50 24.3	1 7 8
Jupiter	1 9 43 59.11	+14 22 43.9	20 59 1
Saturn	1 19 4 10.02	−22 32 40 5	6 21.0

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CONTENTS.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER XII.—[Concluded.]

163. The form of the teeth of the winding wheels and pinions, as usually made, may be classified into two kinds. The one is the usual form of wheel teeth, and the other one, much in favor with the Swiss makers, has a ratchet-like tooth, both for the flat and angular gear. This latter form, if properly made, is by no means objectionable, since these wheels always act in but one direction, so that the shape of that side of the tooth not called into action is of no consequence, and the only consideration for it must be to give it the greatest possible degree of strength. The very thin wheels generally used in Swiss keyless watches fully justified this way of shaping the teeth; but then the natural character of the tooth ought to be an epicycloid on the acting side, with a hollow back just affording the necessary room for the tooth of the other wheel to pass freely. Most wheels of this kind, however, have so strangely-shaped teeth that they make the impression as though taste had a principal share in their construction.

Winding wheels of proportionate thickness may, without fear of breakage, have the common shape of tooth. Certainly the teeth ought not to be too fine, and the flanks and bottom must offer the best conditions of strength. Therefore they must be short, and may be so, since they have only to lead through a very small angle, after which they are relieved in the gear by the next tooth. The sides ought to diverge slightly, thus giving an increase of breadth to the lower part of the tooth, and the bottom ought to be hollow.

164. The size of teeth is, with the keyless mechanisms of the rocking bar category, essentially prescribed by the toothing of the motion work, and in consequence of it, most of these mechanisms have finer toothed wheels than desirable. A little extra wheel, concentrically adjusted upon the setting wheel, and of the same size teeth with the minute wheel, will relieve from all restriction and enable the constructor to use teeth of the proper size. With the mechanisms of the other class, the size of teeth is quite optional.

165. As a material for the winding parts, steel is generally used; and for the pinions no other known metal would prove suitable. With respect to the wheels, and especially the large ones, I always thought steel, when hardened, might not be sufficiently reliable, since nobody can know whether there is not a tendency to break in some part of it. For these reasons I made them of aluminium bronze for a time, but I had to give it up, not that they had given any reason of complaint, but only because customers seemed to prefer the look of steel wheels.

166. The casing of keyless movements requires some extra work as compared with that of key winders. The fixing pin, contrary to the general rule (90), must here be near the pendant, because, if not, the movement could not be put in. In the keyless watches with the

setting parts on the winding axis, I find it a good plan to have this axis removable, and have it secured by a bridge fixed at the edge of the pillar plate. The inner pivot of the axis moves, as usual, in a brass stud riveted into the pillar plate.

The pinion and the setting cannon must have just the necessary freedom in the sinks made for them in the pillar plate, so that they remain in their places when the axis is drawn out, lest they should make the reinsertion of the axis rather difficult.

This arrangement greatly facilitates the casing, and has also the additional advantage that the action of the winding pinion and contrate wheel can be verified without the movement being in the case.

The winding knob is fixed to the outer extremity of the axis in the common way, and the axis is held in its place by a screw going through one half of the pendant, the inner end projecting into a notch turned into the axis. The head of the screw is sunk into the outside of the pendant.

With this disposition, a movement, after taking out the axis, can be taken out of the case and put into it with the same ease as a simple movement. For hunting watches a little allowance must be made for a small motion of the axis in the direction of its length, for the purpose of opening the front cover of the case. For effecting this the shutting spring has a hole through which the axis passes freely, while a shoulder of the same pushes the spring inward by a pressure on the knob.

167. The push-piece in many keyless watches projects from the periphery of the rim of the case. If such is the case it ought to be adjusted in a way as to completely shut the opening in the case. A round pin with a head outside generally answers very well, and so does also a round disc of about half the thickness of the rim, and projecting a little less than half its surface (Fig. 36).

These projecting push-pieces, however, have been much objected to from several points of view. The first and most serious objection was, that any accidental pressure might push the motion work into gear, and thus alter the position of hands or arresting their course. With the large-linked heavy chains worn now, it is not a rare occurrence that a part of the chain gets into the pocket, and by some chance presses against the push-piece. Another objection is, the apprehension that dust may find its way through the opening for the push-piece. This is, however, of no great consequence, for a push-piece fitted in a careful and judicious way will not allow much dust to penetrate in. The projecting push-pieces have also been objected to on the ground of good taste, which will not suffer any unsymmetrical protuberance. This argument is not of great weight.

168. The combined influence of these circumstances has created a desire to invent some means for setting the hands without any external push-piece, or, when keeping this latter, at least avoiding its principal defect—the liability of being pressed inwardly by casualties not under the control of the wearer.

The former category of devices have already been described and treated (136–143). In the latter direction, the purpose is very well attained by some contrivances of recent date.

Some have the external push-piece of the common kind; a small pin fastened into the push-piece, vertical to the direction of its movement, which projects from the rim of the case and reaches into a corresponding notch or hole of the rim of the front cover (hunting case). This prevents any displacement as long as the case is shut. If the front cover is open, the setting wheel can be pushed in and comes out afterwards by self-action, and is again secured by shutting the front cover.

Other watches have a round push-piece with a head, and this latter is prevented from being pushed in by a part of the rim of the front cover which it overlaps slightly. This obstacle is removed with the opening of the front cover as with the before-mentioned one.

Another contrivance of a similar kind is the following: A pipe is soldered into the rim of the case so that it projects a little outside, and the push-piece is a piece of round wire fitting into it, with its outer end flush with the end of the pipe. A slit is cut across the pipe just the width to allow the nail of the thumb to penetrate into it and push the piece inward, which, by any other touch, could not be done.

169. The form of the winding knob is subject to many influences of taste. The watches, the setting of which is done by pulling the knob out, must have such a form as to prevent

any pulling out when winding. But for all the other keyless mechanisms a form of knob should be chosen which allows of applying the force on its greatest diameter. This not only utilizes the most favorable leverage, but also the place where the rifling of the knob is deepest—both circumstances facilitating the winding operation.

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Transmitting Time by Electricity.

NECESSITY FOR GREATER UNIFORMITY IN THE TIME INDICATED BY CLOCKS IN GENERAL—HOW ELECTRICITY MIGHT BE USED TO ADVANTAGE—CAUSES OF PREVIOUS FAILURES EXPLAINED—SECONDARY DIALS A SUCCESS, ETC.

During the first flush of excitement that existed over the successful application of electricity for telegraph purposes, Mr. Bain, of Edinburgh, a practical clockmaker and a skilful electrician, who was early associated with the invention of one form of the electric telegraph, also invented an electric clock with a system of secondary dials, and conceived the following original and brilliant idea. He proposed to the citzens of Edinburgh to lay wires along their streets, thus joining the principal houses in one electrical circuit, and by placing secondary dials in the circuit to distribute time like gas or water, from one central point to the offices, factories, shops, or dwellings of all the inhabitants who chose to avail themselves of his offer. Mr. Bain fixed the total yearly expense at seven shillings and sixpence for each dial used, while the regular price charged by watch and clockmakers for winding and regulating ordinary clocks was ten shillings and sixpence for each clock, independent of the usual expenses of cleaning and repairs. At a later period propositions were made by parties in Berlin to have electrical dials placed in prominent positions in *Unter den Linden* and other prominent thoroughfares of that city, but, like all new schemes of a revolutionary character, these proposals met with much opposition and ridicule from watch and clockmakers as well as the general public; and, for want of sufficient encouragement and support, electric clocks and dials failed at that time to be introduced into general use, although many such clocks were made, and preserved by their owners either for further experiment or as a curiosity. These failures were also in a great measure due to the lack of experience and general imperfections which always accompany the first application of agents for new purposes. Since that period, however, the application of electricity to clocks has been greatly improved, and the necessary experience has been gained in controlling and manipulating the subtile electric fluid, and electric clocks and dials of many different plans of construction have gradually come into use in many of the principal cities of Europe and North America, and some of these clocks are of a very reliable character.

The necessity for a greater uniformity in the time shown by clocks is apparent to all, and many people at some time or other have suffered personal inconvenience from these discrepancies. It would be difficult to find ten clocks in a town that indicate the same time. Uniformity in the time shown by clocks has now become a necessity at all our public offices, at stock exchanges, the various banking houses, railroad depots, large manufactories, and in every situation where it is desirable that the movements of large bodies of people should be guided by one uniform standard, so that their various appointments may be kept with precision. Even in ordinary dwelling-houses a greater uniformity in the time shown by the clocks in different apartments is often desirable. Those of our readers who have had the charge of a number of ordinary clocks in a large building will have experienced the extreme difficulty there is in regulating them so that the hands of each clock will always show the same time. When a number of clocks of the class we generally meet with in public offices, or in private dwellings, have to be regulated to keep time so that at the end of each week there will be little or no variation in the time shown by each clock, people who have not had experience in this kind of work can form but little idea of the difficulty there is, even for a skilful and careful workman to accomplish the desired end. All timekeepers will vary more or less, it being impossible to make one that will run without some variation, and this variation must be checked by altering the regulating screw, or by some other means; but when we attempt to make a small alteration we often make a larger one than is desired, and sometimes it may be in the opposite direction

from what we intended, on account of the screw, or the face of the regulating nut being out of truth. When it is practicable to do so, a mark may be made on the pendulum rod at the top of the ball, and by the aid of an eyeglass we can see how much the position of the ball has been altered independent of the amount the screw has been turned ; but this precaution cannot always be practised, for it often happens that, owing to the situation of the pendulum, we are obliged to turn the regulating nut at random.

The same, or perhaps even greater difficulty is experienced with clocks that regulate from the front of the dial by turning a small square with a key. When small corrections have to be made, the annoyance to all concerned is often most vexatious, and frequently tries the patience of the most amiable of dispositions. In the best constructed regulating apparatus of this class, each turn, or small portion of a turn, that is given to the regulator, cannot always be depended upon to have the same effect on the rate of the clock. In these remarks we are to be understood as referring to making small corrections; for example, two ordinary clocks have to be kept to the same time, and one loses one minute in a week, and the other one, from some cause, gains one minute, which makes the two clocks differ two minutes, and before they can be brought to the same rate it is often necessary to make many alterations of their regulators, and occasionally, during the operation of regulating, a wider difference will exist in the time shown by the clocks than when first we commenced regulating them. People who are annoyed at this difference, but have no knowledge of the real cause, often recompense the best efforts of the most careful workman by blaming him for spoiling the clocks, and consider him the author of this petty annoyance.

In primitive days, when people were willing to have clocks with tall cases, which gave room for a long pendulum, it was a comparatively easy task to keep a number of well-made clocks so that they would show nearly the same time. Public taste has changed, however, in this respect, and clock cases of designs that will not admit of a long pendulum are in popular favor; and as the pendulums are made shorter, the difficulty of making the clocks run regular increases in proportion. The same remarks apply also to our public clocks. In many instances all the accommodation the architect of a building seems to think a clock requires is simply places for the dials ; and instead of that part of the building being built to accommodate the requirements of the clock, the clock has to be constructed to suit the building; which, in some instances, is the fundamental cause of the unreliable character of our public clocks. Timekeepers for scientific purposes are required principally to show a uniformly regular rate. In clocks for terrestrial or celestial surveys a little losing or a little gaining is not of much consequence, so long as the variation is always regular, and the amount known. For the ordinary puposes of life, however, the *uniformity* of time is perhaps a greater consideration in clocks than the absolute regularity of their rates ; and it is our purpose at the present time to ascertain if this object could not be better accomplished by bringing electricity to our aid, thus dispensing with the necessity of a separate pendulum and regulator for each clock—one standard pendulum, placed in some favorable position, regulating the motion of the hands on any given number of dials.

Electric clocks may be divided into two distinct classes. First, those where the electricity is used simply as a substitute for a weight or spring ; where each clock is regulated by its own individual pendulum, and subject to the same variation from that source as ordinary pendulum clocks. To this class belong those different mechanical combinations whereby motion of the clock is maintained, either by the direct action of the electrical current upon the pendulum itself, or through the intervening agency of a small spring or weight, which the electrical current winds up at stated intervals. Another plan is to use the electrical current to raise small gravity arms, or small balls, which, falling against the pendulum, maintain its vibration. We gave a description of a a clock on this plan in the August number of the Journal, which, in the application of electricity to maintain the motion of a pendulum, possesses many decided advantages over other clocks of the construction we now speak of. In the present article it is our aim to direct attention to the other class of electric clocks, commonly known as secondary clocks : those that are not regu-

lated by independent pendulums, but which follow the motion and are controlled by one standard clock or pendulum, either in the immediate vicinity or at a distance.

We take for granted that the reader possesses a knowledge of the electro magnet, and the magnetic system of telegraphing. When the electric current passes through the coil of wire that surrounds the soft iron, the iron becomes magnetic and attracts the armature; and when the current ceases the iron loses its magnetic force, and the spring on the armature pulls it back to its original position. This motion is produced by breaking the connection at intervals, or by closing the connection when a movement of the armature is desired. The spring that pulls the armature from the magnet when the current ceases is attached to a a small silk thread which winds on a spring tight roller, and by turning the roller backward or forward the spring is made stronger or weaker to suit the varying force of the electric current and the consequent power of the magnet. These disturbances in the power of the electric current are caused either by the irregular action of the elements which compose the battery, or by the imperfect conducting power or isolation of the wires when in the open air, during thunderstorms, or when the atmosphere is heavily charged with electricity, for then a portion is liable to be communicated to the wires, and the current is immediately disturbed; and when the atmosphere is filled with moisture the regular electric current is also disturbed, for the moisture dissipates some portion of the electricity. In addition to adjusting the power of the armature spring to suit the varying strength of the electric current, the face of the armature has also to be adjusted, by means of screws, to stand at a suitable distance from the face of the electro magnet. Some of our readers may have noticed telegraph operators making these adjustments on their instruments, and which, by the way, is considered to be one of the most difficult things to acquire in telegraphy, as these adjustments require constant attention to get their instrument to work with certainty. In secondary dials there are no skilful operators stationed at each magnet to make these adjustments; and for want of a proper adjustment of the armature spring to suit the varying force of the current the magnets often ceased to work, and the hands on the secondary dials stopped, to the great annoyance of those depending upon them for time, and much to the discredit of electric clocks in general. These difficulties need not at the present day interfere with the success of secondary dials, because insulated wire can now be had at a comparatively cheap rate which effectually protects the current from all outside disturbances. Improved batteries have also been constructed which give a regular and constant supply of electricity for many months without attention, and one adjustment of the armature and its spring in relation to the force of the magnet, is sufficient for a long time, because a current of perfectly uniform strength can now be maintained at a cheap rate; and even when it does vary slightly, contrivances have been made that prevent it having any effect on the regular motion of the hands.

The construction of the mechanism for moving the hands of secondary clocks have been greatly improved. This mechanism is usually moved by the action of an electro magnet moving once in a minute. In some forms of mechanism, although the magnet and armature worked perfectly, the hands would not always move regularly. Sometimes they would not move at all, and at others they would move two or three minutes at once, which circumstance, although it should occur only once in ten thousand times, which is about the number of minutes there are in a week, rendered secondary clocks unreliable as standards of time. This obstacle has also been overcome by a simple mechanism so constructed that, under any combination of circumstances, it will work with certainty, moving the hands one minute at a time for every motion of the armature as it is attracted by the magnet. There was an arrangement for secondary clocks brought out in England a number of years ago, which we examined critically at the World's Fair, in London, in 1862. This plan was to construct a clock with weights and a train of wheels, and with escapement and pendulum as in ordinary clocks. The weight gave motion to the clock, and the vibrations of the pendulum were controlled by the action of electro magnets placed either at the side of the pendulum or in the centre of its ball. Clocks on this principle are in operation in the United States, but it has always seemed to us that this plan for working

secondary dials was too complicated for the actual benefits derived, more especially in small dials. When the hands on large dials are exposed to the action of the wind, and when an electric current cannot conveniently be made powerful enough to remove them, the clocks must of necessity be made with weights; but, instead of attempting to control the motion of the pendulum by magnets, we consider it a superior plan to dispense with the pendulum altogether, and to release a suitably constructed escapement, at stated intervals, by means of an electro magnet, and an electric circuit that is controlled by the vibration of a standard pendulum placed in a favorable position.

A most vital point in the successful action of secondary dials is the act of closing or breaking the electric circuit, which is the heart of the system, and its action sends a pulsation to every clock or dial in the circuit. Originally the circuit was closed or broken by the pendulum of the standard clock, acting against a spring at the end of each vibration (which plan made a motion of the electro magnet once a second), or by means of a wheel revolving in the clock, constructed of a certain number of conducting and nonconducting substances. These plans were all subject to two defects: they disturbed the rate of the primary clock, and the action of closing or breaking the circuit was not sudden enough. In electro magnets there is a certain amount of electricity remaining in the wire after the current is broken, and which somewhat interferes with the regular action of the armature and its spring. It has been noticed that when the circuit is broken slowly, more electricity remains in the wires than when it is broken instantly; and, in fact, it has been determined that the quantity of electricity that remains in the wires is exactly in proportion to the suddenness with which the current is broken. Mechanism has now been constructed that breaks or closes the circuit in a most rapid manner, while the shock in no way reaches the standard pendulum, or interferes with the regularity of its vibrations. Independent of the bad effects of the slowness of the original methods of breaking or closing the circuit, there was another difficulty in connection with the operation of far more importance than the one we have just mentioned. The act of closing or breaking the circuit had the effect of decomposing or oxidizing the metals that composed the points of contact, and if the oxide was allowed to collect and remain, or the points of contact became dirty from any cause whatever, the electric current could not be completed, and there was no longer power in the magnets. It has been found that the points of contact are decomposed the more readily if the batteries are very strong in proportion to the diameter of the conducting wires, and the elements which compose the battery have also great influence on the rapidity with which decomposition or oxidization takes place. Although this liability to oxidization in the points of contact cannot be entirely overcome, there are certain metals used for the extreme points of contact that are less liable to decompose than others. Many different kinds of mechanical arrangements have been proposed, some of which have been adopted, for keeping the points of contact always bright and clean, and some which we have seen are effective in their action.

In these remarks we have referred altogether to the use of electro-magnetism as a motive power for secondary clocks. Of late years extensive experiments have been made in Boston with a view of applying magneto-electricity, which is the reverse or counterpart of electro-magnetism, for this purpose. This plan has decided advantages over the electro-magnetic system, because in it the magnetism is only produced when it is required and the difficulty of making or closing the circuit is avoided, and, in addition, there is no expense or trouble required in maintaining batteries, and we would judge that for short circuits, such as would be required for a number of clocks inside of one building, this plan would work well.

From the foregoing observations it will be seen that, although in many instances secondary dials may have in the past proved a failure, we have pointed out the primary causes of these failures, as well as some of the means by which the difficulties may be overcome. This branch of our art has been enriched by a gradual accumulation of experience, and we can see no good reason why the benefits of this plan should not be more generally taken advantage of than it is at the present time. There must be a limit to the application of every agency; but with skilful and experienced men at the head of the enterprise, we believe it

to be quite practicable at the present day to carry out Bain's original idea, that all the dials in a large town or section of a city could be made to follow the lead of one standard clock. This standard might be the best that could be constructed, be kept constantly in motion, and regulated to be always within one or two seconds of mean time. By the adoption of this system the inconveniences of winding clocks that require to be placed in out of the way situations would be avoided; and, most important of all, the difficulties connected with keeping clocks to show uniform time would be reduced to a simple mechanical arrangement, like the index of a gas or water meter, and the annoyances arising from clocks showing different time would be entirely obviated.

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Watch Repairing.—No. 4.

BY JAMES FRICKER, AMERICUS, GA.

In our last article we treated of the chain, and as it connects with the fuzee, we will deal with that, and all those parts that belong to it, in this article.

The fuzee receives too little attention at the hands of the majority of workmen. I have known workmen who would polish the balance pivots, bush the small holes, etc., who would never seem to give the fuzee a thought. It is not my intention to enumerate the many different make-shifts adopted by some to make the fuzee answer for the time being, but to give such practical directions for putting in a new one, when needed, or of repairing the old one, when it will answer the purpose of a new one.

Let us suppose that the pivots are worn so that they have too much side shake, the corners of the square are rounded, and the fuzee ratchet is worn out. These three repairs are frequently to be made on one and the same fuzee, so we will put them together and deal separately with the other difficulties; such as putting in a new click, new maintaining power spring, new fuzee or great wheel, new fuzee arbor, etc.

Having satisfied ourselves with the repairs that we intend to make, first see if the depthing of the great wheel and centre pinion is correct before taking the fuzee apart, by putting the centre wheel and fuzee in the lower plate and trying them. This is necessary from the fact that the depth may have been changed by some one, or a new main wheel or centre pinion may have been put in that were not of the proper size.

We will suppose the depthing correct. Take the fuzee apart, remove the old ratchet and the pins that held it on, clean off the oil, file up the square, then stone it with a piece of flat steel wire and oil-stone powder until you have made each side of the square flat, and removed all the file marks; then polish with crocus and oil on a bell-metal polisher; lastly with Vienna lime and alcohol on box-wood or lignum vitæ. Put a brass chuck up in your lathe, which should be not less than $\frac{1}{4}$ of an inch in diameter, and say about an inch in length; make a deep centre with a graver, and cement the fuzee up true, with the upper pivot out, and true it up by such portions of the pivot as have not been worn. When the shellac is cold see if the pivot still runs true; then, with a sharp graver, carefully turn the pivot down until it is true and straight, removing as little metal as you can and yet accomplish the object; also turn up a square shoulder, and at this time face up the end of the square with the graver if it is rusty. Next take a piece of square steel wire, say $\frac{1}{4}$ inch square, and file about three inches of one side (from the end back) perfectly flat, using about a No. 5 Baumel file for this purpose, which side will be used for the pivots; the side that will rest against the shoulder must be so filed as to form an angle of about 85 degrees with the other side, and describe an arc of a circle; file away the top to a gradual taper for three inches from the end. The file marks should all run at nearly right angles to the length of the polisher. Charge your polisher with oil-stone powder and oil, and while the lathe is running rapidly place your polisher on the pivot, keeping it well up to the shoulder, and move it briskly back and forth for a few seconds; then remove it, and clean off the pivot, and see if all the graver marks are eradicated; if not, proceed as before. As soon as you have got all the graver marks out, and have a good surface, clean it thoroughly preparatory to polishing. You will by this time have seen the necessity of having your polisher made with the side resting against the shoulder of the pivot, and with a slight curve instead of straight, as it

is impossible to move your hand back and forth in parallel lines; consequently, with a straight polisher, you would round the shoulders, but with a curved one you can keep them square; and furthermore, it being filed so as to form an angle of a little less than 90 degrees with the side resting on the pivot, you can grind down to a sharp corner.

Make a bell metal polisher, like the steel one, and with crocus and oil for an abrasive powder, proceed as with the steel polisher; clean off the pivot, and then use a finer article of crocus or rouge; again clean off the pivot, and finish with Vienna lime and alcohol on boxwood. Serve the end of the square in the same manner, and your upper pivot and square are finished. It sometimes happens that the square is very much out of true, in which case you will have to turn a centre on the end of it if you have to polish the lower pivot.

Take off your fuzee and reverse it, and turn down and polish the lower pivot; take it off again, and select a brass ratchet of the proper size—one that is large enough for both clicks to rest in the bottom of the spaces between the teeth. Select or make a brass chuck, with a deep hole in it, larger than the fuzee arbor; face it off, cement your ratchet up on this, and true it up by the *outside;* bore out the hole to fit the lower end of fuzee arbor, take it off, and put it on the arbor where it belongs; having first drilled two holes for the pins near its outer edge, and countersunk them on both sides, drill for one of the pins in the fuzee, and force a pin in, and rivet it down; drill for the other, and fit a pin to it. Now the ratchet is fast and true, put the fuzee up in your lathe again, and face off the ratchet, and turn out the centre to allow the shoulder of the main wheel plenty of room; put the maintaining wheel on to the main wheel, and try it on to the fuzee to see if the ratchet has been turned out enough, also to see if you have faced it down thin enough; after which take it off and boil out in alcohol to get the shellac off, then clean the other parts and put them together.

You are now ready to bush up both holes in the plates. First, put the plates together with screws or pins, as the case may be, then put them up in the universal lathe, getting the centre from the lower hole, which was found to be correct in the first examination so far as depth was concerned; bore a hole straight through the upper plate (through the old hole), then bore another about half way through, slightly larger than the hole that goes clear through; the smallest one must be one or two lines larger than the old hole. (In this case, we have supposed that the fuzee was not jewelled.) After taking the plates apart, put a piece of brass wire in the lathe large enough for the largest part of the hole in the upper plate, and fit a bush to it that will fit both sides. To do this fit the wire to the large part of the hole first, then turn down for the smaller part; put the plate on this wire, after having slightly countersunk the lower side of the hole, and rub it in with a burnisher, using considerable pressure. Next drill a hole in the end and bore it out with a cutter to nearly the right size, then face it off, cut off the wire on the other side with a saw, reverse the plate, cement it upon a brass chuck, or put it in the universal lathe, and finish up the other end of the bush, leaving it projecting as much above the plate as the other parts will allow. The reasons for this are made apparent in the articles on "Friction" in late numbers of the Journal. In finishing up the upper end of the bush, if you will use a graver or cutter with not only a sharp edge, but one that is polished, and then turn the lathe very slow, and take off a very slight chi , you will produce a *polished cut;* then if you will take a little Vienna lime, wet with alcohol, on the end of a piece of pegwood, and run the lathe fast, you can put such a gloss on it as will not only look beautiful, but will not tarnish in a long time.

Having satisfied yourself as to the end-shake of the fuzee, you will then bush the lower hole. Of course you will have fitted the fuzee pivot to its hole by broaching it out slightly (as it was bored nearly large enough), and then polishing the hole with a round broach, which not only polishes the hole, but hardens its surface. Remove the fuzee bridge and broach out the hole, file up a piece of wire to fit it, cut it off a little longer than the hole, and rivet it well in, being careful not to deface the bridge; screw it back again, and put the plates together. Sometimes it is as well to bush the upper hole in the same way. Centre in the universal lathe by the upper hole; centre and drill for the lower hole, and finish the outside of it while it is up in the

lathe; take it out and take the plates apart, and fit the lower pivot, and try the end-shake. To give it enough put the lower plate back in the universal lathe and face off the bridge, or bush rather, until you get it right; or if you choose you can cement the bridge upon your brass chuck in another lathe, which at times is a very convenient way of doing.

If the fuzee is jewelled top and bottom, fit a bush into the hole in the plate (supposing the party did not wish to pay for a jewel), and give it a shape similar to a jewel with steel setting, and polish it up nicely, and it will look very well; or make a brass bush just the shape of a jewel, and fit it into the steel setting, which also looks well. We frequently put them in either way. If the lower bridge has a jewel screwed in, proceed same as with the upper bush. If it was rubbed in, shape the bush so as to rub it in also. To do this knock out the old setting and turn up a bush just like the old setting, only making it solid; drill a hole through the centre, or, better still, have it solid; next cement the bridge upon a brass chuck, and then put the bush into it, having chamfered off its outer edge; cut a slight groove around the hole in the bridge, and with a burnisher rub in the bush, screw the bridge in, put the plates together, and put up in the universal lathe and drill the hole in the lower bush, and then fit the pivot and get the end-shake as before described. All this is some trouble, but it is quickly done, and when well done it will be a satisfaction to you and of value to the watch.

We sometimes find the groove in the fuzee so worn from having carried a chain that was not the proper thickness, or that has been filed by some one, so that the chain will at times slip when winding. When it will admit of it, the old groove can be recut so as to make it answer a very good purpose where the owner of the watch will not pay for a new fuzee. Without taking the fuzee apart, put it up in the lathe with a spring chuck, or cement it upon a brass one if you choose. If you use cement you had better take the fuzee apart; fasten your rest a little below the centre and parallel to the spindle, then with the cutter in your right hand commence at the largest part of the fuzee and take a light cut, carefully turning the lathe with your left hand so as to make it go very slow, keeping the cutter against the fuzee until you wish to run out at the snail. By repeating this process several times, you will get the fuzee into a tolerable condition, at least so as to hold the chain as good as ever.

You can make a cutter out of an old thick graver. Draw the temper, then file the end up square; then file away the metal on the right-hand side of the graver (when the cutting end is pointing from you) for about a quarter of an inch back from the end, leaving a thin cutter on the *left* about the thickness of the chain; now temper and sharpen it, having cut away the lower side enough to give the edge a good cutting angle, which for brass, can be very obtuse. This little tool, with a little practice, will enable you to improve many an old fuzee that you would otherwise have to replace by putting in a new one, and last as long as the balance of the watch. Some one may have a better plan of renovating an old fuzee than this, but certainly not a more expeditious one, as it will not take three minutes to make the old groove quite passable in this way.

This subject (the fuzee) has taken up more space than was expected, consequently we will have to continue it in our next.

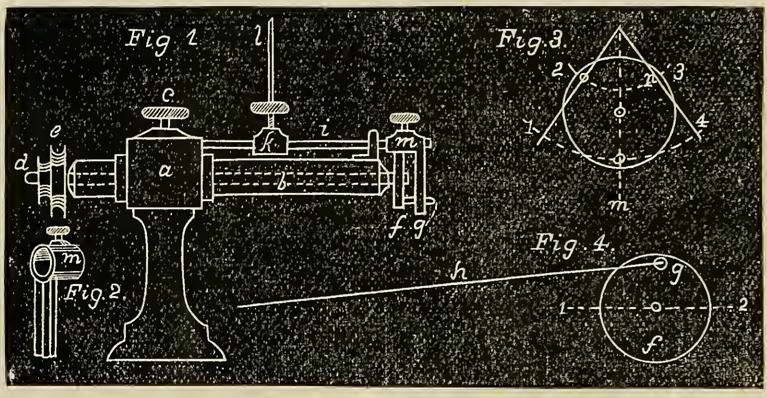
Theory and Practice.

Thousands and thousands of inventions come from the fertile brains of inventors that are entirely useless to the practical world. The crude thought is put in form by a draftsman, the patent obtained perhaps, and the machine constructed of working size, only to prove a partial, or perhaps total failure. Points that were plausible in the plan, or perhaps that were not thought essential, develop, on practical application, conditions altogether unlooked for, and repeated failures must ever be the precedent of perfection. This well-known fact should not deter inventors from diligently prosecuting investigation, but it should caution them not to bring to public notice crude attempts.

As an example of this class, we produce the drawings of a little polishing tool, or "wig wag," for the convenience of watchmakers,—to all appearance an excellent arrangement, only, like some other things, "it won't work."

In the drawing, A is a brass column, to be

fastened upon the rear of the bench. The machine is to be actuated by a band from the live spindle lathe. Through the square head of this column is the hollow bar *b*, secured in place by the set screw *c*. Through this hollow bar extends the mandrel *d*, having upon one end a cone of pulleys *e*, and the other a metal collar or disk *f*, from the face of which a steel stud *g* projects, being inserted near the periphery of the disk. To the top of the bar is fastened a cock *h*, which carries one end of the steel arbor *i*, the other end being pivoted in the square head of the supporting column. The end of the arbor *i* projects through the cock sufficiently to allow to be slipped upon it the short tubular collar *m*, with its set screw; to the front end of this collar is secured a right-angled slitted arm, represented in perspective at Fig. 2. In the slit of this arm, which lies in front of the disk *f*, the stud *g* moves freely as the mandrel *d* is revolved, changing, in a very simple manner, the rotary into reciprocating motion; the stud at each revolution traversing the entire length of the slit.



The arbor *i* has upon it a tubular collar *k*, fastened in any desired position by the set screw *l*, which is indefinitely prolonged upward, forming a rocking bar, to which motion is imparted by the stud in the revolving disk *f*, the length of stroke depending upon the place upon the bar *l* from which the motion is taken; the greater the distance from its centre of motion, the greater the length of stroke. By a jointed connection with this rocking bar a pitman extends forward to the lathe, and upon it is the usual square polishing block.

It will at once be seen that, when this machine is actuated by a band from the cone upon the lathe, rapid vibratory motion is communicated to the polisher. And it seems simple and effective, *but* it does not work well. The reason for this defect is found in the fact, which the maker overlooked in his construction, that the stroke of the polisher in one direction is made so suddenly as to partake of the character of a blow or jerk, and its passage over the revolving pivot is nearly, if not quite, as rapid as the pivot's revolution. This will be better understood by consulting the diagram Fig. 3, by which it will be seen that the disk *f*, carrying the eccentric stud *g*, must travel nearly three-fourths of a revolution to carry the slitted arm *m* from one extreme to the other, or from 1 to 2, while for the other stroke it only travels from 2 to 1. But that is not all. The near approach which the stud *g* makes to the centre of revolution of the arm *m* while passing from 2 to 1, moves it with a rapidity proportioned to the diameter of the two circles 3 and 4, which the near and far points of *m* describe in making the journey back and forth. On account of the very short radius of the circle 3, the journey of the polisher is really performed in an inappreciable space of time. This difference diminishes as the length of the arm *m* is increased, for the relative parts of the circle of revolution travelled over by *g* at each rotation gradually approximate equality, till, were it extended to infinity, the difference would become infinitely small. The inventor was evidently led into this mistake by the necessity of giving a large arc of vibration to the arm *m*, with as small an eccentric as possible, and when the machine is slowly revolved the error spoken of is not apparent, but when run at the high speed which is intended, it becomes so pulsatory as to become dangerous to minute pivots; in fact will jump entirely off the pivot,

unless kept down by a detrimental pressure.

The change of direction of impulse in the polisher should be gradual, the highest speed being attained in the middle of the stroke. This removes the tendency to jump, and is a condition beautifully fulfilled in factory machines for the purpose, where they are carried by an eccentric, or by a crank and pitman, as shown at Fig. 4, *f* being the circle of revolution, *g* the stud carrying the pitman *h* to which the polishing block is attached. The quiescent points, being in the line 1, 2, gradually increasing in speed till in the position indicated by the drawing, and gradually diminishing to the second quiescent point, and repeated identically during the second half revolution.

Should the inventor succeed in remedying this defect in the little machine, it will be a very useful and much to be desired adjunct to the repairer's machines for perfect work.

The Story of a Watch.

BY THE AUTHOR OF "REMINISCENCES OF AN APPRENTICE."

I was made in London about the year Queen Victoria was born, at an establishment where the proprietor had a theoretical and practical knowledge of the business, and every workman had to be a complete master of the branch of business he professed. The caliper from which I was made was one of the best, and all my different parts were arranged with a view to general utility, combined with strength where strength was required. I had no patent improvement whatever, and contained no complex arrangement to counteract the evil effects of faults that had no business to exist. To sum up my various properties, I was a sound, well-made lever watch, adjusted to positions and moderate changes of temperature, had heavy gold cases, and cost £30. My owner used me well, was regular in his habits, and every eighteen months or so left me at the shop where I was made, to be cleaned and looked over. The watchmaker charged his own price for his trouble, and my owner paid it cheerfully; and for several years the most perfect satisfaction prevailed among all concerned.

One evening, after my owner had wound and placed me in the usual position for the night, he remarked to his wife what an excellent watch I was; that I had never failed to do my duty, or in a single instance led him astray since he had received me as a marriage present fifteen years ago; and that I was the best watch that was ever made, and he would not part with me for a hundred pounds. Little did he suspect, when he made that remark, how soon he was to lose me; and as little did I think, while basking in the sunshine of his praises, what terrible adversity was in store for me. Early the next morning, as my hands were between one and two o'clock, a man wearing a mask cautiously opened the door of the room, and I saw at once that his visit meant mischief. After glancing hurriedly around he came to the dressing table, took all the jewelry that was laying around, snatched me and my owner's wife's watch from our pockets, and took us and some silver plate found in another part of the house to quarters in London where stolen goods were received, and before the sun rose that morning my cases were a shapeless mass of gold, and my works locked up in a drawer with a quantity of miscellanous movements of all grades, from the finest pocket chronometer to the cheapest class of Liverpool or Coventry duffers, and in a few days we were all packed up together and sent to New York.

In New York I got new gold cases and by some means was smuggled into the channels of legitimate trade, and was soon bought by a steamboat captain who wanted a good reliable London made watch. For over a year I gave my new owner the best of satisfaction; he was loud in his praise when he had occasion to talk about me, and once when boasting about my regular running to a grain merchant the proposal was made to purchase me. He said he had tried a great many different kinds of watches, and he never could get one to run near as well as I was said to, and finally a bargain was concluded, and I was sold for more than twice my actual value. The grain dealer had occasion to travel considerably in the Western States, and somehow I could not run to please him any better than any of the watches he had carried previously. He regulated me at every town he came to, and attributed my apparent variation to the shaking I had received

when he was travelling. He certainly did travel over a great many rough roads, but I was able to stand it all without changing my rate very much. The real cause of the trouble was the difference of the time shown by what was acknowledged to be the standard clocks in the different towns and cities he visited; and when his watch did not show the same time as the clocks, he concluded the watch was wrong, and regulated it accordingly; and in this way he kept constantly shifting my hands and poking at my regulator.

Now, I do not think that a watch acts any worse than a human being when placed in a position of this kind. If a watch is constituted to pursue a certain line of conduct, it cannot help doing so if people will only let it alone; but any unnecessary interference, however well meant it may be, always works mischief. I was doing my best to please him and could not do it; and he was under the pleasant delusion that he was helping me to run regular, while his actions were the very thing that prevented me from doing so. One evening he forgot to wind me, and, as a natural consequence, I stopped. He concluded at once that I needed cleaning, and took me to a watchmaker, remarking that he was to be sure and clean me well, as I had never run right since he got me. "Oh, yes," says the watchmaker, "I will shine it up good;" and he kept his word, too, for the scrubbing he gave me with chalk and a hard brush was perfectly fearful, causing irreparable damage to my fine gilding. It was the first time chalk had ever been used to clean me, and the watchmaker left much of it in my pinions, pivot holes, and other places, and when he handed me back to my owner I was in a far worse condition than before I was cleaned. In the course of a very few weeks I stopped again, from being so choked up with chalk and hairs from the watchmaker's brush, and my owner took me to another watchmaker, who, of course, told him that I required cleaning. My owner could not understand how it was that I required to be cleaned so soon, and evidently regarded this watchmaker as an impostor; but as there was no other in the town, and I had to be made to run somehow, he left me with him. Now this watchmaker treated me very well; cleaned out all the particles of chalk, polished my pivots, arranged my screws in their proper places, and also polished and blued the heads of those that were damaged, and, as far as he was able, restored me to my original condition. When my owner called to get me, and when the bill was presented to him, he flew into a great passion, and instead of only thinking this really honest watchmaker to be an impostor, he now believed him to be one in reality, because he was charging three dollars for what my owner considered to be the same work as the man who had "shined me up good" had done so expeditiously, and charged only a dollar and a half. If the watch-wearing public only knew a little more about their watches, how much better and pleasanter it would be for all concerned.

After this double cleaning the natural inference would be, that I would be sure to run well; but I did not please my owner any better, and the primary cause of the whole trouble was, he kept continually altering the position of my hands and regulator. At last he came across a watchmaker in a large city who thoroughly understood what was the matter. He said that I was not properly compensated for heat and cold, which was invariably the disease that afflicted every watch that came into his hands. Now this was the most scientific man that had ever handled me. He had an oven constructed according to his own ideas, and which differed from every other contrivance of the kind for testing the rates of watches in various temperatures. His arrangement for producing cold was equally peculiar, and he was altogether so very scientific that he could use nothing but Reaumur's thermometer to mark the different degrees of heat and cold. I was first put through the stereotyped process of cleaning, but the owner of the establishment did not attend to that personally, leaving it to be executed by a subordinate. After I had been cleaned, and when he was putting me together he bent one of my third wheel pivots slightly, and it was with some difficulty that I managed to keep moving. To persons possessed of minds of such a high scientific order as the owner of this establishment, the train of a watch is of little consequence; it is in the adjustments where all the science comes in; consequently he saved all his energies to use in that direction. Now, the ordinary adjusters of watches to heat and cold are content if they can get us to run regular in moderate changes of temperature; but this idea

would not satisfy the man whose clutches I had now got into. He argued that if a rope had to sustain a hundred pounds weight it would be safer to have it made to bear the strain of two hundred pounds, which, of course, is agreeable to common sense as well as science ; and consequently it must also be safer for a watch that usually runs in a given number of degrees of heat or cold to be tested in double that number. This also appears common sense, but it was not the science practised by my maker, who, for extreme degrees of temperature, considered a secondary compensation was necessary. This little omission, however, was of no consequence whatever to the professor who now had me under his charge. He tried me in a temperature below the freezing point, and then in another temperature which nearly melted the shellac that held the jewels in my pallets, and in this manner continued to persecute me for nearly a month; but being originally a good watch I was able to stand it all, and was not much the worse. At last this professor of baking and freezing examined his book, added up the figures in the different columns of the page devoted to my record, and I was pronounced to be perfect. My owner cheerfully paid the large bill that had been incurred, and it was considered morally certain that I would run regular this time.

How little dependence is to be placed on human calculations. Our fondest hopes, which to-day seem on the point of being fully realized, are to-morrow shattered to pieces. The clocks in the towns of the different States that my owner visited in the course of his business still continued to show different time, and of course I was still considered to be running bad in proportion to the amount I varied from the different clocks. Besides, I had a bent third wheel pivot now, which sometimes caused me to stop altogether. In the course of a year I was at half a dozen different watchmakers, who all said that I needed to be cleaned, and they all cleaned me; but I was not fortunate enough to fall into the hands of one who examined me thoroughly to see really what was the cause of my stopping. One day I stopped after being only two days out of a watchmaker's hands. My owner tried another watchmaker in a town a number of miles distant, who told him the usual story, that I needed to be cleaned; but my owner maintained that it could not be possible, as I had been cleaned but two days before. This man wanted a job, and was not particular about the means he used to get it, and under the pretence of examining me and trying the power that was on my different wheels, with the point of a peg, dexterously removed a portion of the dirt from under the nail of his thumb, and showed it to my owner as having been taken out of my works. Of course this was conclusive proof that I needed cleaning, and I was put through the process once more; but my third wheel pivot was not straightened that time either, and of course I continued to stop running at intervals. My owner was now thoroughly disgusted with both me and the watchmakers, but was induced to try another one, who was recommended by a particular friend as being a mechanical genius.

This individual belonged to the family of "born watchmakers," and was one of those few who are possessed with that amount of knowledge of watches, and skill in correcting their errors, that only those inspired by nature can be expected to enjoy. He conversed freely about watches in general, and was very severe in his denunciations of regular watchmakers in particular. When my owner handed me to him, and told the whole story of my bad behavior, the natural genius looked at me patronizingly, poked my wheels with the point of a piece of wire quite regardless as to whether he was scratching them or not, then became absorbed in deep meditation for a few minutes. At last he pronounced that my gears (as he called them) did not run deep enough into each other, and that they had too much back lash. My owner was astonished to hear of such a radical defect in my construction, and appeared a little incredulous at first, for he naturally wondered why the regular watchmakers had not discovered this defect before; but the natural watchmaker clinched his argument by giving him the piece of wire and the eye-glass to try for himself; and sure enough there was a play or shake between the teeth of my wheels and the leaves of my pinions, and the born watchmaker convinced him that this shake prevented the wheels from acting constantly on each other. When the watch was being carried about, and especially if he was wearing it when riding on horseback, or in a railroad car, the play

in the gears was sure to allow the wheels to move backward and forward, and consequently they could not move regular, and when the wheels did not move regular how could the watch be expected to run regular? My owner soon saw the point of this sensible argument, and when he did make the discovery he became perfectly frantic with joy, and nearly made himself as conspicuous in the neighborhood as that ancient philosopher did, who, regardless of ordinary toilet arrangements, ran through the streets of his town shouting "*Eureka.*"

Of course it was immediately decided that my wheels were to be made to run deeper into each other; the natural watchmaker was empowered to do the work, and in a few days the vandalism was completed. My destroyer first proposed to hammer my wheels and stretch them enough to prevent shake in the teeth, but finally abandoned that idea and bushed up the pivot holes and run the wheels in anew. My frames were fearfully abused in this operation; not one of my pivot holes were straight or properly fitted, and not one of my wheels was upright, but the wheels all worked as deep into the pinions as they could possibly be made to run, and my owner superintended the alteration in person. After this alteration was completed another one was found to be necessary. My mainspring was too weak and a stronger one had to be put in, which was so thick that the mainspring box could not hold the usual number of turns and give the necessary freedom for the spring to work. The accurate adjustment of the fuzee was entirely destroyed, but this defect was never thought to be of any consequence. At last I was put together, but it was awful hard work for me to keep moving; and were it not for the wide pivot holes I never would have been able to run at all. The points of the teeth of my wheels butted against the backs of the leaves of my pinions; the bent third wheel pivot, which in reality was the original cause of my stopping, was never observed, and was bent still; but the wide pivot holes accommodated, in a certain degree, all these defects. I managed to keep moving, and went regular enough to please my owner, who was now settled in one place, and compared me with one clock all the time. Although I was not going one half as regular as before, he firmly believed that my construction had been greatly improved, and that another laurel had been added to the many already won by this natural watchmaker.

[TO BE CONTINUED.]

Robert Hooke.

This celebrated natural philosopher and inventor was born in the Isle of Wight, England, on the 18th of July, 1635, and for the first seven years of his life was in very infirm health. His father, who was minister of the Parish of Freshwater, educated him under his own roof, as he had been such a sickly child that he was not expected to live. He was at first intended for the church; but, after beginning the Latin Grammar his health became so weak, and he was so much subjected to headache, that his parents despaired of making him a scholar. Being thus left to the direction of his own genius, he amused himself in the formation of toys, and he even succeeded in the construction of a wooden clock that exhibited, in a rough manner, the hours of the day. This circumstance led his parents to the resolution of putting him apprentice to a watchmaker, but owing to the death of his father, in 1648, the plan was not put into execution. He was placed for a short time under Sir Peter Sely, the celebrated painter, but remained under his instruction for only a short time, and was then sent to Westminster School, where he made great progress in Latin, Greek, Hebrew, and other Oriental languages. He also made considerable progress in Euclid, and, as Wood informs us, he invented thirty different methods of flying in the air.

In the year 1650 or 1653, he went to Christ's Church, Oxford. In 1655 he was introduced to the Philosophical Society there, and was employed to assist Dr. Willis in his chemical experiments, and afterwards labored for several years in the same capacity with Mr. Boyle. He received instructions in astronomy from Dr. Seth Ward, Savilian Professor of that science in Oxford, and was henceforth distinguished for the invention of various astronomical and mechanical instruments, and particularly for the air-pump which he contrived for Mr. Boyle.

In consequence of perusing Ricciolus's *Al-*

magest, which Dr. Ward put into his hands, he was led, in the years 1656, 1657, 1658, to the invention of the balance or pendulum spring, one of the greatest improvements that has been made in the art of Horology. Some consider Abbè Hautefeuille and Huygens to be the inventors of the balance spring for watches; but it was not till 1674 that Huygens claimed the invention, and the Abbè Hautefeuille had merely suggested the idea about this date, and there is no doubt but what Hooke invented it fourteen years previous to these gentlemen. Dr. Hooke mentioned his discovery to Mr. Boyle, who showed it to several other prominent gentlemen of the day, who so readily approved of it that they formed themselves into a company to take out a patent for the invention. The papers were actually drawn up about 1663, by which it was provided that out of the first £6,000 of profit Dr. Hooke was to have three-fourths, of the next £4,000 two-thirds, and of the rest one-half; but the other partners in the patent very improperly insisted upon the insertion of a clause in the agreement, giving to any of themselves the sole benefit of whatever improvements they might make upon his invention.

About the same time Hooke contrived the circular or conical pendulum, which was shown to the Royal Society in 1663, and which was afterwards claimed by Huygens. The establishment of the Royal Society afforded to Dr. Hooke numerous opportunities of extending his reputation. He published, in 1650, a small tract on the ascent of water in small tubes by capillary attraction, in which he showed that the height of the water was in a certain proportion to their bores. A debate arose on the subject in the Royal Society in April, 1661, but Dr. Hooke's replies were considered so satisfactory, and raised him so high in the estimation of the Society, that in 1662 he was appointed curator of experiments to that distinguished body. In 1663 he drew up a list of inquiries for the use of those who might have occasion to visit Iceland or Greenland. Those in respect to Iceland are numerous and interesting, and one is particularly deserving of notice: "Whether spirits appear; in what shape; what they say and do; anything of that kind very remarkable and of good credit," etc.

In January, 1664, the Royal Society settled upon him £30 a year for life, for his labors as curator of experiments, and in the same year he was appointed to succeed Dr. Dacres as professor of geometry in Gresham College. In 1665, at one of the first meetings of the Royal Society, Dr. Hooke produced a very small quadrant for observing the minutes and seconds by means of an arm moved with a screw along the limb of the quadrant. His explanation of the inflection of a direct into a curvilineal motion was read before the Royal Society in the year 1666. In the same year he laid before the Society a plan and model for re-building the city of London, which was destroyed by the great fire; and though his plan was not executed, he was appointed one of the surveyors under the act of Parliament—a situation in which he realized a considerable sum of money, which was found after his death in a large iron chest, that appeared to have been shut up for thirty years.

In the year 1687 he suffered a severe loss by the death of his brother's daughter, Mrs. Grace Hooke, who had lived several years with him; and the distress of his mind was still further increased by a Chancery suit with Sir John Cutler respecting his salary. In 1691 Archbishop Tillotson employed him in contriving the plan of the hospital near Hoxton, founded by Robert Ash, and out of gratitude for his services that distinguished prelate obtained for him the degree of M.D.

When the Chancery suit with Sir John Cutler was determined in his favor in 1696, he was so overjoyed that he left an account of his feelings in his diary, expressed in the following manner: "I was born on the 18th of July, 1635, and God has given me a new birth. May I never forget his mercies to me; while he gives me breath may I praise him."

In addition to the inventions we have already mentioned, Dr. Hooke invented the areometer, the spirit level, a recoiling escapement for clocks, and also applied the screw for dividing astronomical instruments, and invented the clockmaker's cutting engine. He also invented the marine barometer and sea gauge, and the method of supplying air to the diving bell, a quadrant by reflection, and a clock for registering the weather. In addition to these and numerous other inventions, Dr. Hooke proposed a steam engine on Newcomen's principle,

and a pendulum or a drop of water as a standard of measure. He was the first to observe the secondary vibrations of sounding bodies; that a glass touched with a fiddle bow threw water into waves at four points, and that the fundamental sound was accompanied by its harmonies. In order to induce him to complete some of his unfinished inventions, the Royal Society requested him, in 1696, to repeat most of his experiments at their expense; but the infirm state of his health prevented him from complying with their request. During the last two or three years of his life he is said to have sat night and day at a table, so much engrossed with his inventions and studies that he never undressed himself or went to bed. Emaciated with the gradual approach of old age, he died at Gresham College on the 3d of March, 1702, in the eighty-seventh year of his age, and was buried in St. Helen's Church, Bishopgate street, his funeral being attended by all the members of the Royal Society who were then in London.

Rogers & Bro.

In answer to a correspondent in the last number of the Journal, we stated the fact that this firm had recently added considerably to the productive power of their factory, but a more extended notice was justly due them. From the commencement their business has steadily increased from year to year, rendering it impossible for them to meet their orders with that degree of promptness satisfactory to the customer. In addition to the engine spoken of, giving them an increase of about two hundred horse power, they have made extensive additions to their machinery, much of it of entirely new and improved designs, enabling them to largely increase the production of their goods.

Their salesrooms at 203 Broadway have also undergone extensive improvement, as well as considerable addition in extent, which, together with the many new and tasteful designs in goods added to their stock, render their establishment well worthy the attention of the trade. Like all others who have built up a reputation on a specialty, they find their trade marks have been extensively counterfeited; and the only safe way for those that want Rogers & Bro.'s goods, is to buy them of the makers or of first-class jobbers, who fill orders with the *genuine* goods, stamped "*Rogers & Bro.*"

Friction.

Ed. Horological Journal:

It was my intention to remain a silent observer in the pending controversy on the above subject; but in response to the request and closing remarks of B. F. H. in the last number of the Journal, I would respectfully state my position with regard to the subject of friction and its bearing upon the adjustments to position. I am well aware of the difficulty of making a public confession, but I shall do this the more conscientiously inasmuch as he charges me with a share in the cause, if he is misled in his views. To be brief and candid, I would mention at the outset that I am thoroughly convinced of having been in error in my views concerning friction at the time of writing my first article on adjustments. In this respect, then, I cannot feel particularly flattered by his eulogies, though I am obliged to him for his good opinion.

Long before writing the article above named I had been in the habit of adjusting watches to position, *i. e.* causing the balance to describe equal arcs in all positions by simply flattening the ends of the pivots more or less. This I did, not with any fixed idea as to the principles underlying, but simply because I knew from experience that this operation would have the desired effect. I was not then as familiar with the subject and laws of friction taught in mechanical philosophy as I have since become, and feeling no particular need of knowing the whys and wherefores, my mind was not led to reason about it until I wrote the article on adjustments, when I thought it necessary to explain the phenomenon. Then it was when I made the mistake that, instead of going to work and studying up the subject of friction for myself, I was rather led by the remarks of other writers on the subject of adjustments to conceive the view that friction is proportional to the surfaces in contact, and thus fell into an error, the consequences of which I little dreamed of when I made those statements. But "be-

hold how great a matter a little fire kindleth." When, however, my attention was called to the subject, it did not take me very long to see that I was wrong in my ideas about friction, nor much longer to find the true solution for the adjustment to position. And now I am truly sorry if I have been the innocent cause of Brother B. F. H.'s mistake; but it will be seen from his articles that he carried the mistake much beyond the scope of my remarks on adjustment, and solely on his own responsibility. Still, I would ask his pardon, and recommend him to carefully reconsider his premises, if perchance he also may "see the error of his ways."

It is not my object here to review anything which has been said in this controversy on either side, but I would say in reply to B. F. H.'s inquiry addressed to myself, that he seems to overlook the fact that the principles of friction, as they have been discussed in the controversy, have nothing at all to do with the adjustment of a watch; or rather, that the adjustment of a watch is accomplished independently of whether friction is proportional to pressure or to surfaces, as shown in Mr. Gribi's article, page 134, present volume. The fact that we differed in theory at one time did not prevent either of us from adjusting to position by the same means—that of flattening the ends of the pivots. In my article on adjustments I simply gave a wrong explanation of the phenomenon, thus having built a false theory upon a known fact. We often build false theories upon known facts. But the fact that Newton's emanation theory concerning light was a false one does not prove that the sun did not shine just as radiantly in Newton's days; so the two antagonistical theories concerning adjustment to position do not disprove the fact of the adjustment.

As regards the real questions of the controversy, whether friction is proportional to pressure, independent of the extent of surfaces in contact, or not, I am obliged to bow to the overwhelming testimony in favor of the former. There is here and there a minor authority, such as Parker and others, who seem to teach that friction is increased by increasing the surfaces, but without any demonstration at all; while all the best German, French, and English authors on mechanical philosophy positively and unmistakably teach and demonstrate the contrary. It is very evident that the laws of friction are not an exact science; but respecting this particular characteristic of it they must all unanimously agree, and I am humbly of opinion that B. F. H. is quite alone in the world of intelligent mechanics who hold a contrary view. His experiment with the tail stock of a universal lathe, I am free to state my belief, would not stand one moment's test before the scientific world, because it is subject to compound or binding friction, which he does not distinguish from simple or free friction. I would advise him, as I see he is an expert in casting metal, to cast a model of brass or iron somewhat in the shape of a Swiss Jacot lathe; then bore the holes for the broaches straight, and considerably larger than the shaft intended to be used; then make cylindrical bushings of different lengths, the holes of which must be straight and parallel, fitting the shaft accurately but free, and cut them longitudinally in two, making thus of each two half holes; then cut also the top of the model so that only one-half of the bore remains, which will enable him to place conveniently bearings of different length into it; make a shaft of equal diameter in its length, and this, with a pulley in the middle between the bearings, and a small string, with a scale to receive weights wound around it, should give the best results possible to be obtained.

As regards the making of experiments to test the doctrines of friction in a watch, or even in a clock, I believe it is impossible to obtain satisfactory results within the compass of so small a mechanism; at least such experiments are too difficult, and too much subject to variations for which we are not able to account; besides, we are all, or at least most of us, obliged to work for our daily bread, and under such circumstances we naturally avoid unprofitable work; but, to say the least, experimenting for the benefit of others, even when the results are satisfactory enough, is plainly not only unprofitable, but a thankless job. Too many of our brethren—and, it must be said with regret, even of the better class of workmen—are singularly unwilling to learn; some, it would seem, are incapable of reasoning correctly, others plainly think they don't *need* any information, and thus reject and oppose everything they hear. Bet-

ter would it be if they could take good advice, to treasure up everything they hear, show a disposition to be grateful to those who are able to impart knowledge, remembering that all we know is derived from *external sources of information.*. HOROLOGIST.

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Laws of Friction Under Difficulties.

ED. HOROLOGICAL JOURNAL:

I will not take part in the friction question, but because "Clyde," as an outsider or looker on, sides with the stronger party, I must remind him of the well-known fact, that the laws of nature cannot always be followed with advantage. Even correct science for the theory cannot always give the result which is expected, in practice. The trouble with us all is, not enough thought at one and the same time. As regards a certain law in friction, lubrication must be dispensed with before advantage can be had from it. Nature makes timepieces without friction, and with this power or advantage gains several others—having no oil obstacle to contend with, as man has.

There is nothing so bad in the mensuration of time as pressure and lubrication (one necessitates the other), whether from large force in the escape-wheel direct, or from inclined planes, or both causes meeting, as they generally do. Neither inclined planes, "club teeth," or dead beat, should be tolerated where rate power is to be a leading feature in a timekeeper. The idea that watch oil can be such (so superior or perfect) that it remains fluid, is wrong: the best does not long remain, in the very nature of things, worthy the name, no matter how good when applied, as will hereafter appear. Dame Nature, as said before, has vacuo for her balances to vibrate in, and has no gravity to oppose; showing that from only two obstacles come all our troubles as regards rate power. Why man persists in competing with her, under such odds, is past my calculation.

Unfortunately, then, with man oil, and consequently dirt also, are necessary (I say necessary because they cannot be avoided) in the wearing departments of an escapement; hence the smaller the areas of contact in the rubbing surfaces, other conditions being equal, the smaller will be the resistance called friction. This is proved in the English lever inclined plane action as compared with the Swiss and American "club teeth" area of contact. Experience teaches that the pressure on inclined planes is too large for dry rub to give satisfaction in the rate of the watch; we are then forced to the expedient of oiling, and *take* satisfaction for the time being; but, with the employment of a lubricant several additional causes of error come into power—such as collecting and retaining particles of sand; grinding away the polish where smoothness of surface is wonderfully important; adulterating the oil with metal as well as other dust, etc.; and to cap the climax in these direct and indirect obstacles which come in with the necessity of lubrication, the watch is alternately heated in the pocket and cooled over night. Cold after heat always leaves the oil inferior to what it was before cooling; deteriorates it by inches, as it were, even were it not ruined with foreign matter.

Now, as the balance pivots in some degree share in these circumstances, it is best to reduce the areas of contact in the vertical position as much as is consistent with durability, for the purpose of improving the rate power; but to make this suspension resistance *equal*, is an absurd attempt or effort to substitute the effect of isochronism with equality in the *extent* of the vibrations. This resistance to the balance must be allowed to exercise its normal eccentricity, and the watch must be made independent of its influence on the *motion* of the balance, instead of making the *resistance* equal under all the circumstances of position, wear, dirty oil, cold, etc., which is not only impossible, but a useless waste of genius, *a la* perpetual motion making. Pivot friction would not even remain the same resistance to the balance in the *same* position of the watch, but would increase as the areas of contact were larger, coarser, and dirtier. Constancy in friction is impracticable, and we expose our ignorance when we expect it, even in the one positioned marine chronometer, with chronometer escapement. All that man can do, in his best direction, is to approach the ideal. In small pressure oil is not required; or, if it were, there is a much smaller percentage (in small friction) of inconstancy. Many watchmakers will say, "Nonsense;" but these things can be made to tell their *own* stories much better than I tell

them here. I do not make imaginary causes of variation; I only try to remember some of the real ones. Next, I hear, probably, "Matters need not to be so curiously considered;" but the property known as time is curious also, to say the least.

There is much to be learned; but these mysterious ghosts (causes of error that lie below the surface) can be made to speak, or squeak to us; and their lank witches (languages), and worse dial acts (dialects), be interpreted. A balance clock, with the cylinder escapement, compensation, horizontal position, going barrel motor, isochronal vibrations (so far as motor is concerned), tells the changes in the resistance to the balance nearly as exact as a thermometer does those of temperature; more friction, more loss in the rate; and, in continued going of the machine, the phenomenon goes on in an accelerating ratio, and represents the antithesis of what is known as "acceleration." The lever escapement cannot be used with success for such a friction measurer, because the resistance to the lift pallet (jewel pin) decreases in about the same accelerating ratio as some of the other frictions increase; thus establishing an antagonism between two of the above-mentioned ghosts—acceleration and the reverse. The man who can make deductions will see that when the lever watch keeps its rate, these two ghosts are hard at it, and are balanced; the watch begins to alter its rate as one gets the ascendancy over the other, which may sometimes not occur in a year; while in large pressure the scale may turn in a month. It is necessary to state that this article has only to do with *rate-power*, variation, and some of its causes.

J. MUMA.

Hanover, Pa.

[There is no subject at present, in which the readers of the JOURNAL are more deeply interestod than that of friction, and everything tending to elucidate any points in the controversy will be read with interest. Our correspondent, Mr. Muma, has a method of expressing himself that is peculiarly his own, and, from its quaintness, to the careless reader his meaning may at first seem a little obscure; but his communication will well repay a careful and thoughtful consideration.]

Differences of Temperature in Clock Cases.

ED. HOROLOGICAL JOURNAL:

The remarks of your correspondent "Clyde" in reference to the different metals in their relations to latent and sensible heat are undoubtedly true. Allowing for that difference, there are errors still which the ordinary construction of the mercurial pendulum cannot correct—small, I grant, yet still sensible—and affecting unfavorably the rate of the clock. Suppose the difference in the properties of mercury and steel in these respects will compensate for one or two degrees of variation of temperature between the top and bottom of the pendulum, yet when the difference is either greater or less, it cannot do it.

I have not made my observations with sufficient connectedness to give them to you for publication; but they are accurate enough to show a decidedly variable and unequal condition of temperature at the top and bottom of the pendulum. I will give you a few days record in August.

	7 A. M.		12 M.		9 P. M.			
	Top.	Bottom.	Top.	Bottom	Top.	Bottom.	Mean Difference.	Extreme
Mon....	72.5	71	81	80	81.5	77	2.33	4 5
Tues..	78.	76	77	75	78	74	2.66	4
Wednes.	73.5	72	83	82	82	78	2.17	4
Thurs...	77 5	76	79.5	78	82	78	2.33	4
Friday .	72.5	71	76	74	79	75	2 5	4
Sat.....	72.	71	80.5	79	78	74	2.17	4

This table is about a fair sample of the fluctuations for summer weather; but the winter shows much larger.

From my limited experience it would seem desirable to have the temperature within the clock case as little liable to change or fluctuation as possible.

Where expense does not prevent, I would suggest that the case be made on the principle of the ice-chest; that is, with an inner and outer case, with air, or some other equally good non-conducting material, enclosed between them, making the case roomy and as nearly air-tight as may be.

By this construction the temperature at the

top and bottom of the case would be nearer equal, and less subject to outside changes.

Weymouth, Mass: FAIRBANKS.

[The above table of the variation of temperature inside Fairbanks' clock case for six days in the month of August shows that there was a decided difference between the top and the bottom, and, most important of all, the difference was not always uniform. We would express a hope that Fairbanks will continue his experiments, and we take this opportunity of reminding all our readers interested in this question to make similar observations so far as they may have opportunities for doing so, as has already been suggested in the columns of the JOURNAL, and send the results of their experiments to us about the month of January for publication.

The idea of making a clock case on the same principle as an ice-chest has already been put into practice without improving the steadiness of the rate of the clock to that extent such a reasonable alteration in the construction of the case would be supposed to produce.]

Automatic Watch Pocket.

ED. HOROLOGICAL JOURNAL:

In the August number I observe a communication from J. Muma, Hanover, Pa., entitled Neuchatel Observatory Trials, in which he refers to an automatic watch pocket which he has used occasionally ever since 1862, when testing watches. This pocket he says is kept in motion by mechanism so contrived that it produces all the different changes of position, and also the usual shaking and jerking that watches are subjected to by different classes of wearers, and is also claimed to be better adapted for testing the running of watches than the natural wear of the watch in the owner's pocket. As a description of such a contrivance would be of great interest to many belonging to the Horological profession, and would be of much service to those members of our trade who have occasion to adjust fine watches, I would express the hope that Mr. Muma will tell us a little more about his automatic watch pocket, if he can do so without compromising any of his own individual interests in the matter.

New York City. R. C.

Long and Short Screw Drivers.

ED. HOROLOGICAL JOURNAL:

I am greatly indebted to you for publishing my inquiries regarding the cause of the extra power we obtain when turning a screw with a long screw-driver over what we experience when turning the same screw with a shorter screw-driver. The remarks made on this subject by Mr. Gorgas, of Hudson City, in your last issue, attributing the cause of this phenomenon to leverage, I think is scarcely a correct explanation. At one time, I thought myself that leverage might have something to do with this question, but on studying the actions of the different orders of levers that I am acquainted with, none of them appears to be analogous to the action of a screw-driver. I do not want to put myself too much forward, or to contradict the opinions of men having greater experience in the trade than I have, or to appear to be unreasonably inquisitive; but will Mr. Gorgas please explain a little more minutely how a screw-driver acts as a lever in turning a screw? I have an impression that a lever is powerless unless used in conjunction with a fulcrum. What constitutes the fulcrum in the action of a screw-driver turning a screw, and at what point is the fulcrum placed? I am obliged for the explanation which you gave on this question, and although I consider it a reasonable one, I would like to learn more on this subject. E. D.

Hartford, Conn.

Ring Gauges.

ED. HOROLOGICAL JOURNAL:

I notice in the last number of your journal a communication in relation to a "Standard Ring Scale," and from it I infer that "B. F. H." is not aware there is *already* a standard gauge *in use*, and fast being introduced throughout the States.

I refer, of course, to Allen's Standard Gauge, which was adopted by the manufacturers and jobbers more than a year ago, and has been sold by them and tool dealers ever since. It is justly regarded as much the best thing of the kind ever made, and I am glad to know that several thousands have already been sold,

and that their introduction is being extended throughout the Union.

The advantages of this gauge over a thin scale, as suggested by "B. F. H." are very obvious, and is not only more accurate in taking measurements, but is more simple and convenient, and besides the scale for sizing rings, it has one for cutting to lengths and altering sizes.

Its universal use will be a great benefit to the trade, and, as now made, are as perfect as will ever be needed.

E. F.

Long and Short Screw-Drivers.

Ed. Horological Journal:

Every little while somebody asks anew the old question, "why a long handle screw-driver has more power than a short handle one." I see the Journal has not escaped that question. On the principle that asking questions is the most direct way of obtaining information, good may come of it. For myself I do not see how, in this case, any principle of mechanics or philosophy can be very extensively developed or illustrated by this experiment, and I have never heard the question asked without retorting, "how do you know it is so?" I have heard very ignorant philosophical discussions got up by some one asserting that a vessel of water weighs no more if a live fish be added to the water, so I view the screw-driver controversy as being based upon a popular fallacy, or fancy, which grew up naturally and easily. Every one knows that with a large screw-driver screws are more easily moved than with a small one, and of course large screw-drivers commonly have long handles. A screw-driver with long handle affords an opportunity to apply more force, although the point and handle are of the same diameter, either by the addition of force from the other hand, or it may be by the peculiar position of the screw operated upon allowing more pressure to be applied in the direction of the axis of the screw-driver, either from additional weight imparted by the body of the operator, or by the more favorable position allowing greater pressure upon the tool by the hand and arm alone; in which case it is easy to give the long handle credit for power which in fact it receives from some other source and simply transmits to the screw. Before considering any learned argument on the subject I should require more facts than I have ever yet seen or heard of, to prove that the assertion of there being more force in a long handle than a short one was true.

R.

Cleveland, O.

Answers to Correspondents.

L. G. G., *Halifax, N. C.*—The subject of apprenticeship about which you inquire is in a very uncertain and unsatisfactory condition. The entire absence of apprenticeship laws, or wherever they do exist, the total disregard of their execution, leaves the whole country in a condition of anarchy on this subject. The rules and regulations with regard to apprentices which the Trade Unions have endeavored to enforce upon many of the handicrafts, still further interfere both with the legal and natural conditions which would otherwise prevail. The subdivision of labor into distinct branches, and the introduction of machines into all the trades, have greatly modified the old apprenticeship regulations. In the olden time a silversmith was expected to take the coin and with his own hands turn out the dozen finished spoons. Now the silversmith of modern production is not expected to do that; he must be an adept in some special branch of the business, and may be, and probably is, quite ignorant of any other department. Burnishing, stoning, polishing, raising, planishing, are each distinct departments. A watchmaker of the olden times was expected to do every thing in the clock, watch, jewelry, and silversmith line; now the modern watchmaker knows no more of the jeweller's art than of the enameller's, is not even required to be able to make a wheel or pinion; they can all be bought, and only need to be fitted. This state of things has vastly increased the number of trades, and at the same time diminished the amount of knowledge required to perfect each of these class artisans. An architect now has no need to know how to use the chisel, auger, and mallet. He goes from school into an architect's office and studies the principles of construction, orders the construction to go on, and it goes on, while his hands are as white, and the skin as thin, as the

merchant's. The carpenter, on the contrary, gives no thought to principles; he takes the plans and specifications, follows the measurements implicitly, only being required to learn the use of tools, to hew and mortise, and square and bore; so that the old seven years apprenticeship, and the tramp for another definite period, which alone entitled a mechanic to call himself master, are not required, and in consequence the rules for apprentices which did obtain are now mostly obsolete. In our own business, there seems no fixed time, terms, or conditions. The necessities and wishes of the parties themselves form the basis. If a watchmaker needs the assistance of a boy he gets one on the best terms he can. If a boy wishes a place he does the same thing. Free trade is in this matter eminently the rule. Probably three years is as little time as any master can take a boy for, and remunerate himself for the trouble, loss and bother which are incident to boyhood—and the gratuitous labor of three years is more than most boys are nowadays willing to give except in rare instances, where the love of the occupation is in excess of the love of clothing, billiards, tobacco, whiskey, and fast trotters.

One great difficulty which ambitious young men experience who are really anxious to get on in the profession, is the scarcity of competent instructors, particularly in places remote from great commercial centres; for such, a good plan now seems to be, to make the best arrangement possible with the best local talent in the business for primary instruction, say one or two years; then in larger cities there are always higher class workmen who will take under instruction such partially educated mechanics, and give them trade price for all work they do. This will about pay living expenses for a year or two more, during which time such proficiency ought to be attained as to make work for the trade remunerative or command a salary which shall be satisfactory. It is not possible to answer your question positively as to "what is just and equitable between master and apprentice"—for the circumstances are as various as are the cases. It is, perhaps, safe to say that the young man who gets his ordinary expense for economical living and clothing, paid for the first four years' services, ought to be well satisfied to lose that much time in consideration of suitable instruction and advancement in the art. The prevalent desire to be rich before the age of thirty spoils many a good mechanic; he can't spend his time for nothing, but must be making money. This is really the reeking unhealthy soil out of which grows such a prolific crop of half perfected workmen; these impart to another crop of the same sort a portion of what they know, and so the quality goes down, down, down, till the title "mechanic," which should be an appellation of honor, becomes the synonym for ignorant labor.

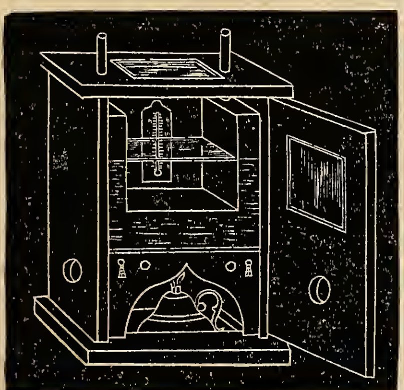
J. M., *Eufala, Ala.*—Jewellers' rolls are hardened as any other piece of steel, being carefully heated up to a cherry red, and quenched in a cistern of tepid water. The immersion should be vertically—that is, the roll plunged endwise into the water, and moved about until cool. This plan gives the fewest chances for warping the roll. They may then be tempered to the color desired, after which replaced in the lathe, and the journals and face turned *perfectly true* with a diamond tool. They are then put in place in the frame, and a copper plate charged with emery and oil interposed between them and revolved in opposite directions, while the plate is shifted back and forth longitudinally until the surfaces are perfectly true and parallel. An improved method of grinding consists of grinding three rolls together, the surfaces of all three being kept in contact by pressure, and each revolving at a different speed, one of them being constantly shifted back and forth longitudinally, which insures parallelism between all three surfaces. A very good test of the parallelisms of the surface of rolls, is to run through them under pressure a strip of writing paper; if it passes without being distorted from the flat, they are good. Another good test is the passage of light; bright day-light will pass through a crack so narrow as to be water-tight; if the line of light seen through between the rolls is of continuous width and brightness as they are revolved, they may be assumed to be correct. The surest proof, however, is in the use of them upon thin metal. Good rolls are a precious tool, and should be treasured as the apple of the eye.

The new lathe you inquire about is not yet produced, the parties interested preferring to have it as near perfect as possible rather than

introduce it in a crude condition. The fault you speak of regarding split chucks does not pertain to the chuck, but to the improper use of it; used as it ought to be, they will maintain their truth almost forever. For valuable suggestions on that subject you are referred to an article in No. 11, Vol. III., on the subject. No better proof of the utility and truth of the split chuck is needed than the fact that they are the basis of most of the lathe work in the American watch factories.

R. F., *Chicago, Ill.*—You can have the ring of wood to go round your large dial made by G. Autenrieth, 371 Pearl street, New York city. We have seen a lathe at his factory in Long Island City, that is specially constructed for turning such rings, from the smallest size up to twelve feet in diameter.

S. Richards, Jr., *South Paris, Me.*—The following diagram will enable you to make for yourself an oven that will answer your purpose. The reservoir may be made of tin or copper, and with a space of two inches on the bottom



and one inch on the two sides, with sufficient room below the reservoir to allow of a lamp. An oven six inches square is largo enough for your purpose, and should have a glass shelf in the middle for receiving the movement. It is found that the temperature is more even with the reservoir only on two sides, and of course it is easier to make. On the top and in the door is a double glass having an air chamber between, which prevents the condensation of moisture, thus at all times affording a clear view of the movements, as well as the thermometer suspended on the back of the case. When the water is sufficiently heated to raise the temperature of the chamber to 100°, a very small flame will be sufficient to keep it there; and even if the flame should go out altogether, it will remain very near that temperature for hours. The case may be made of any soft wood—pine is as good as anything.

The oven from which this drawing was taken, was made by Mr. J. M. Bell, of Hudson City, for his own use, and almost any watchmaker can make one for himself, of course getting a tinsmith to make the reservoir; or, if it was necessary to get it made, the expense would probably not exceed five or six dollars.

H. F., *Savannah.*—Holes may be bored through glass as easily as through soft steel by using an ordinary-shaped drill, made fire-hard, and wetted with spirits of turpentine, in the same manner as oil is used in boring steel; but the motion of the drill should be a little slower than when steel is being bored. Holes may be readily pierced in the centre of Aneroid barometer glasses and similar work by simply turning the drill with the forefinger and thumb. For larger holes the drill must be turned slowly in a lathe, or by some similar means. Great care must be exercised when the *point* of the drill is coming through the glass, because it is at this juncture that the most of the danger of breaking the glass exists. Just before the point of the drill comes through, the drill should be sharpened, for by doing so the risk of breaking the glass is materially reduced. A three-cornered drill stands better than an ordinary-shaped one when large holes have to be bored. After the point of the drill has come through, bore from the opposite side, and at short intervals bore from each side, for by so doing there will be but very few chips made on the edge of the hole. Of the many different methods of boring glass, we have found the above to be the most reliable, and also the quickest. In this manner we have bored the holes in many dozens of glass dials, and seldom met with an accident. If the edge of the hole requires to be perfectly smooth, as sometimes happens in the case of winding holes, they must be ground afterwards with emery and water on a piece of lead running in the lathe, and shaped like a male centre.

G. A. I., *Ct.*—Your idea for a caliper is a good one, but is already anticipated in the invention of Mr. F. Waaser, of the firm of Waasser & Danziger, a full description of which,

with diagram, was given in No. 7, Vol. III. of the Journal. This firm are now having them manufactured in Europe, and in some respects are superior to those first put on the market. The "*Essence Lemoine*" is a cleaning fluid recommended by the Society of Watchmakers, Paris, and is for sale by the same firm.

E. S. K., *Findley, O.*—The receipt you send for cleaning silver plate, show cases, etc., is good, and is in use by many. We used the same thirty years ago, but, like you, do not remember to have seen it in print.

Fill a bottle two-thirds full of aqua ammonia; add to it common whiting sufficient to make a thin paste. If fine silver ware is to be cleaned, it is better to add prepared chalk instead of common whiting, which often contains impurities that scratch a fine surface. Apply it with a sponge or soft rag. When dry, polish off with chamois skin or a soft cloth.

Mr. Spaulding, of *San. Francisco*, has sent us a sample of lathe belt which he has had in use many years, and which he finds answers an excellent purpose. It is cut from thin pliable calfskin, a full 16th of an inch wide, and *twisted* into a round cord, the ends fastened by a figure 8 hook; he says it runs perfectly smooth, *never* wears out, and is easily shortened, to secure the requisite tension, by unhooking the ends and giving it a few more twists. He prefers it to all others he has tried.

"Subscriber," *Minneapolis*, would have found the question he asked about adjustments, answered in previous numbers of the Journal, had he "subscribed before" as he "now regrets he did not." You can draw the temper from steel without discoloring it by heating it in oil, which prevents contact with the air.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For November, 1872.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be Subtracted from Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Friday	1	67.02	16 18.87	0.034	14 44 19.07
Saturday	2	67.14	16 19.29	0.000	14 48 15.63
Sunday	3	67.25	16 18.90	0.034	14 52 12.18
Monday	4	67.37	16 17.71	0 068	14 56 8.74
Tuesday	5	67.49	16 15.71	0.102	15 0 5.29
Wednesday	6	67.61	16 12.90	0.136	15 4 1.85
Thursday	7	67.73	16 9.26	0.170	15 7 58.40
Friday	8	67.85	16 4.80	0 205	15 11 54.96
Saturday	9	67.97	15 59.50	0.239	15 15 51.52
Sunday	10	68 09	15 53.37	0.274	15 19 48.07
Monday	11	68.20	15 46.42	0.308	15 23 44.63
Tuesday	12	68.32	15 38.63	0.343	15 27 41.19
Wednesday	13	68.44	15 30.00	0 378	15 31 37.74
Thursday	14	68 56	15 20.53	0.413	15 35 34.30
Friday	15	68.69	15 10.23	0.448	15 39 30.85
Saturday	16	68 80	14 59.09	0.483	15 43 27.41
Sunday	17	68 92	14 47.11	0.518	15 47 23.97
Monday	18	69.03	14 34.28	0.552	15 51 20 52
Tuesday	19	69.14	14 20.63	0.587	15 55 17.08
Wednesday	20	69.25	14 6.15	0.621	15 59 13 64
Thursday	21	69.36	13 50.84	0.655	16 3 10 20
Friday	22	69.47	13 34.72	0.689	16 7 6.75
Saturday	23	69.58	13 17.79	0.722	16 11 3.31
Sunday	24	69.68	13 0.07	0.755	16 14 59.87
Monday	25	69.78	12 41 58	0.788	16 18 56.42
Tuesday	26	69.88	12 22.32	0.820	16 22 52.98
Wednesday	27	69 98	12 2.32	0.850	16 26 49.54
Thursday	28	70.08	11 41.59	0.879	16 30 46.10
Friday	29	70.17	11 20.15	0.907	16 34 42.65
Saturday	30	70.26	10 58.05	0.935	16 38 39.21

Mean time of the Semidiameter passing may be found by subtracting 0s.19. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	7 15 51.2
☺	Full Moon	14 17 8.5
☾	Last Quarter	22 17 45.3
●	New Moon	30 6 34.7
		D. H.
☾	Perigee	6 9.1
☾	Apogee	21 5.9

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D. H. M. S.	° ′ ″	H. M.
Venus	1 16 22 51.32	−22 31 1.6	1 38 6
Jupiter	1 10 3 10.07	+12 48 0.5	19 16 2
Saturn	1 19 10 15.28	−22 25 32 8	4 25 3

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CONTENTS.

Finishing and Lacquering Brass Surfaces.

NECESSITY FOR USING LACQUER.—HOW FINE LACQUER IS MADE.—HOW BRASS SURFACES ARE PREPARED AND POLISHED.—USE OF POLISHING STONES.—HINTS ON MAKING EMERY STICKS AND STEEL SCRAPERS.—METHOD OF LAYING ON THE LACQUER.—DIFFERENT KINDS OF BRUSHES, ETC.

The custom of lacquering the brass work of our larger, and also moderately-sized time-keepers and machines, or instruments of a similar character, cannot be too highly recommended, and this practice may also be applied with great benefit to many of the brass tools in use in our business. When properly executed, these brass surfaces are coated with a thin covering of a substance nearly as hard and smooth as polished glass, which prevents oxidation and tarnish, and renders any dirt or other foreign matter which may collect on the lacquered surface to be easily and expeditiously removed. Of late years it has become common to plate many articles connected with our business with nickel, and for steel articles it has proved to be very suitable. So far as protecting the surfaces is concerned, it is just as good for brass, but the white color which it gives is not always desirable. Nickel-plated marine chronometer boxes which have been in use for a short time never look so clean as those which have been well lacquered. They possess a kind of dirty white appearance, which is as unpleasant to the eye as a piece of polished silver that has become dirty, and contrasts as unfavorably with a well-lacquered box as a piece of polished silver that has been finger-marked does with a finely polished piece of gold. But, while advocating a more extended and judicious use of lacquer, we are not to be considered to be unfavorable to the use of nickel in instances where the white color is not considered objectionable. Lacquering, although an exceedingly simple operation, is seldom executed in a proper manner, and it is our object at the present time to give some plain, practical directions that will enable any-one, after having a little practice, to finish brass surfaces in the most approved manner, and cover them with a pleasing and lasting protection.

The base of all lacquers is a resinous substance, known in commerce as stick-lac, and which can be purchased at almost any store where dye stuffs are sold. Stick-lac is in the form of small rough brown-colored lumps, about the size of the point of the thumb, and is found attached to the branches of a certain kind of tree that grows in Assam, in the East Indies, and when bought at the stores a small piece of the wood of the tree is found in the centre of the lump, from which it derives its name—stick-lac. Seed-lac is the stick-lac broken up into small pieces, and appears in a granulated form. Lump-lac is seed-lac liquefied and formed into cakes. Shellac is the purified lac, which is made by heating seed-lac in strong canvas bags. The pure liquefied lac drops through the pores of the canvas on to a flat surface which produces the familiar substance known as shellac, while the twigs of wood and all the larger lumps of insoluble matter are left inside the canvas bag. In making good lacquer it is best to use the stick-lac as it comes from the tree, because in its

other forms it is frequently adulterated with some of the softer and cheaper kinds of gums of the same color, and which is very injurious to the lacquer, rendering it soft and easily rubbed off. The stick-lac should be broken into as small pieces as possible and then dissolved in 95 per cent. alcohol in a well-corked bottle, occasionally shaking the bottle, and after a few days strain the liquid through a fine linen cloth or some similar substance. The liquid strained off will be of a deep red color, but in this state it will be found to be unsuitable for many purposes owing to the darkness of its color, as in many instances it is not desirable to change the color of the work being lacquered. Although a very slow and tiresome process, the best way to take the color out of the lacquer, and at the same time to retain its original hardness, is to expose the bottle containing the liquid to the rays of the sun for a sufficient length of time. White lac can sometimes be purchased that has had the color taken out of it by a chemical process, and for many purposes it does very well; but lacquer made from this white lac is never so hard, nor stands so well as lacquer that has been made from stick-lac dissolved in strong alcohol, and the color taken out by the rays of the sun. In some instances, however, it is desirable to change the color of the brass a little, and the deep red-colored liquid will be found to be suitable for some purposes, either alone or mixed with a decoction of gamboge or annatto, the former giving a yellow, and the latter an orange color. In order to produce a golden color, about two parts of gamboge are added to one of annatto; but these coloring substances may be separately dissolved in the tincture of lac, and the color required may be adjusted by mixing the two solutions in different proportions. There are sundry other materials from which a due mixture will produce like colors, such as turmeric, saffron, dragon's blood, etc., but we consider gamboge or annatto to be the best coloring for the lacquer required in our business. Some kinds of the cheap prepared lacquers are almost entirely composed of coloring substances, with very little lac for a basis, and this is one reason why work lacquered with it becomes in a short time dull and streaked in appearance. The main secret of the fine hard lacquer which we see on some old clock dials, on the back frame and pendulum bobs of old English spring clocks, and on old astronomical instruments, is due to the fact that the lacquer was made from stick-lac as it was taken from the tree, and any of the softer gums necessary for coloring was used but sparingly.

The preparation of surfaces previous to laying on the lacquer is one of much importance, for any defect in the finish of the surfaces will show through the lacquering. In the common brass-finishing business, and also in Yankee clock-making, much of the brass work is prepared for lacquering by dipping it into a mixture of nitric and sulphuric or other acids; but we do not consider the question of dipping to come within the scope of the present article, as it is only very fine surfaces we propose to deal with. In all kinds of work of this class, whether it be flat or circular, the main object in view should be to have the grain of the polish as regular as possible. Fine polishing is best and quickest done by using bluestone, or what is known in the United States as Scotch stone. Bluestone is imported from Germany, and Scotch stone from Scotland, and both kinds may be had at almost any of the material or tool stores. There are various qualities of the Scotch stone, but those pieces that are of a dirty white color, and having yellow or blue speckled marks through it, are the softest and cut the smoothest. Either bluestone or Scotch stone can be cut into strips of the necessary shape by means of a saw, and ground perfectly flat afterwards on a piece of sandstone with water. With one of these pieces, and a plentiful supply of water, all the file marks should be polished out of the brass, and the stone should be handled precisely in the same manner as a smooth file is used; and if any small particles of brass should adhere to the stone, it must be rubbed off by means of another piece of stone, else the brass particles will be found to scratch the work. Of late years the practice of polishing fine brass work without using polishing stones has become quite common among a certain class of workmen; and probably the necessity for using water with the stone is one reason why it is omitted; but we have never tried any other method of polishing by which we could do first-class work quicker, better, or *flatter*, than by a judicious use of polishing

stones to prepare the surface for the final finish.

In certain instances a fine scraper can be used very advantageously in polishing. In circular work the planishing tool is a familiar example. These tools, whether they are intended for flat, round, or hollow surfaces, should be ground with a perfectly square cutting edge; that is to say, they should not be ground to an angle, like common turning tools, as they are sometimes ground, because when they are square they cut much sooner. The cutting edge should be of the smoothest and finest description, because it communicates, in a great measure, the same quality to the surfaces of the work smoothed with it. Small, short, or hollow circular surfaces can be finished in a good lathe by this method quicker and better than by any other method whatever. The same principle is also applied to very thin, flat surfaces. A piece of hard sheet steel, having a square and smooth cutting edge, is better adapted for this purpose than the three-cornered scraper ordinarily used, and it can also be used with good effect where surfaces are large in many instances previous to using a polishing stone.

After the surfaces have been smoothed with a polishing stone, all that is necessary to be done is to make the grain of the polish straight, and for small work this can be done best by using emery sticks of fine emery paper, pasted on to flat pieces of wood, and two or three rubs is all that is necessary to make the surface ready for lacquering. The general use of emery paper wrapped round a file is a slovenly and wasteful manner of using the paper. One sheet of paper cut up into strips and pasted on to smooth strips of wood, will do ten times more work than when it is used wrapped round a file, and it will do flat work much better. Emery sticks are made by mixing glue with emery, and spreading it on flat strips of wood, but it is more convenient to use emery paper, and instead of gluing the paper on to the wood to fasten it on with ordinary beeswax. The beeswax holds it firm enough for use, while it admits of its being easily removed when it becomes necessary to put on a fresh piece of emery paper. The paper may be spread on to the stick very conveniently and smoothly, by pressing it over a smooth roller, or a piece of brass tube revolving in a frame, or even rolling the roller on a flat, clean bench, will do. The emery sticks should be used dry, with no oil put on them, as in this kind of work oil has a tendency to cloud the polish. On very large surfaces, such as large clock frames, dials, etc., emery paper pasted on wood will not be found suitable, and the emery paper should be wrapped tightly round a large piece of flat cork, the work being first prepared in such a manner that only a very little rubbing with the emery paper will be necessary. To those who have been in the habit of using oil on emery paper for the last finish, we would ask them to try the very finest quality of paper without oil, and notice the difference it will make in the smoothness and regularity of the finish, and the quickness with which the work is accomplished, over the method of using oil. As a general rule, the polish left by emery paper, employed as above, represents the best surface for lacquering; but it has sometimes a pleasing effect to polish the thin edges or hollows in certain classes of work, very bright. The practice of "swirling," or "spotting" surfaces, is never resorted to in fine work, but it is very convenient, and has a pleasing effect on surfaces which have not been evenly and flatly polished, as it hides these defects. It is also a quick way of giving a pleasing appearance to cheap work, and is very suitable for work that requires to be handled a great deal, because marks or scratches do not show as readily on spotted surfaces as on plain ones. From the above remarks it will be seen that all that is necessary for preparing fine work for eitheir pale or colored lacquering, is a skilful use of the polishing stone, or the scraper, and fine dry emery fastened on paper or wood in the manner already described.

Assuming that the lacquer has been made according to any of the methods described in the second paragraph of this article, and that the surfaces have been prepared and cleaned, which will be no difficult matter, when they have been polished by the dry method, the next step is to lay on the lacquer; but before laying it on, a cup must be provided to contain a little of the lacquer when it is poured out of the bottle. A piece of wire should be fastened across the centre of the mouth of the cup, so that when we dip the brush into the lacquer we

can press the brush against it, and the superfluous lacquer will drop back into the cup. The brush best adapted for ordinary lacquering is one of the smallest size generally used by painters in laying on varnishes. The brush should not be too long, and for most purposes it is best to be moderately stiff; at least beginners will find this kind of brush best suited for them. The work to be lacquered should first be heated by means of an alcohol lamp, or a gas stove, to about a blood heat, and brushed over with alcohol or very thin lacquer. This causes the following coatings of lacquer to flow more easily and spread more readily over the surface of the work. The work should then be heated again to such a degree that it can be touched with the back of the hand without causing pain, and then the brush applied to it and covered with a coating of lacquer. Circular work is the easiest for beginners to practise on. This work, whether it is revolved in a lathe or between the finger and thumb, should be turned slowly and the brush pressed gently against it, gradually moving it from one end of the work to the other. Heat is again applied, and the operation repeated again and again till the coating of lacquer is of the desired thickness. Whether the lacquer is intended to color the brass or not, it should be made very thin with alcohol and the brass coated over with it at least half a dozen or more times, heating it between each coating to that degree of heat that the back of the hand cannot be long held on it without causing pain. If the metal be too hot the lacquer will be burned, and have a rough brown appearance; and if it be too cold it will present a dull, dead look. The art of obtaining the fine gloss which is so pleasing to the eye, and is an evidence that the work will wear well, is in a great measure due to the operator being able to judge of the exact quantity of heat to give the metal while being lacquered. If any of the coatings of lacquer are burned, or if they are put on unevenly, the lacquer must all be rubbed off the work by means of a cloth and alcohol, and the operation commenced anew. Common lacquering is generally accomplished by one or two strokes of the brush, but good lacquering, designed to stand for a length of time, is but a slow process, and requires much patience.

In lacquering flat, irregular formed surfaces, such as cocks, bridges, or work of a similar nature, precisely the same directions are to be followed as in lacquering circular surfaces; but in this kind of work the great danger to be avoided is the lacquer collecting on the edges and spreading in irregular quantities. The benefits of first coating the work with alcohol, or very thin lacquer, becomes greater in this kind of work, causing the lacquer, when it is applied, to flow more easily and regular. The brush must be laid on to the work very light, and with a slight curved motion at the beginning of the stroke, so that it will miss the sharp edge of the work by which a portion of the lacquer would be pressed out and flow irregularly over the edge. The brush must then be drawn straight and with equal pressure along the surface of the brass, and lifted off at the instant it reaches the other edge. In moderately broad surfaces a brush the full breadth of the work should be used; but in very large surfaces, and especially where there are a number of large holes in the work, an ordinary brush is not suitable. The best kind of a brush for this purpose is one made in the following manner: Take a piece of wood a little broader than the work to be lacquered, and make it into the shape of an ordinary whitewash brush handle. Then cut a slit into it lengthwise with a thick saw; next take a narrow strip of clean flannel, as long as the wood is broad, and fold it the longest way; then take a piece of white nankeen cloth and fold it round the outside of the flannel, and put them both in the slit cut in the wood, with their folded edge outward, and fasten the cloth to the wood by means of screws passing through the side. Before fastening tight, however, a piece of straight wire, about a quarter of an inch thick, must be put through the bow of the folded cloth and the cloth pulled tight against the wire so as to make it smooth and straight. After the cloth is fastened tight to the wood the wire is pulled out and it is fit to be used as a lacquer brush. The woollen cloth holds the lacquer, while the nankeen cloth prevents it from flowing too freely, and presents a smooth surface to the metal that is to be lacquered, while it also prevents any particles coming off the woollen cloth on to the lacquered surface. This kind of a brush must not be dipped into a bowl of lacquer, but the lacquer put on to it by means of a common brush. In this manner large flat surfaces are

lacquered very beautiful. When work is newly lacquered the lacquer is soft, and the work ought to be exposed to a gentle heat for a short time to evaporate the alcohol and harden the lacquer. Small gas cooking stoves are very suitable for this purpose, and it will be found that after newly lacquered work has been baked a little, any little unevenness in the laying on of the lacquer will be much improved.

Such is a full exposition of the elements and principal details of the art of lacquering brass instruments for horological, astronomical, or for other purposes, and any of our readers who may have occasion to use lacquer, will, after a little experience, be able to practise the art by carefully attending to the above instructions.

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Reminiscences of an Apprentice.

OUR ELECTRIC CLOCK.

I do not know whether it was that, during the first year of my apprenticeship, my time was not considered to be of much value, or whether it was because "Our Maister" could not be troubled all the time watching me and showing me the way to do things properly, but occasionally he would set me on a high chair and make me read the newspapers aloud while he and "our journeyman" were busy with their work. I rather liked this part of the business; in fact at that period it was about the only part of it that I did like; and to me it was a welcome relief from the usual work of making pins and screws, polishing clock-frames, and other abominations of a like nature. On one of these reading occasions my eye caught the heading of a paragraph which read as follows: "A Clock with its Pendulum in Edinburgh, and its Dial in Glasgow!" "What!" exclaimed "Our Maister;" so I read again, "A Clock with its Pendulum in Edinburgh, and its Dial in Glasgow," when I was interrupted from reading further by a loud and derisive laugh from "our journeyman," who stopped work and seemed to be greatly amused with the idea of anything of this kind being done for the first time outside of London. If I had read about a clock with its pendulum in London, and its dial in Patagonia, or in Central Africa, I feel assured that "our journeyman" would have believed all about it, and probably would have told us all about the great things he used to see done in London, which were nearly as wonderful; but the fact of such an achievement being accomplished so near to our own doors was too much for his credulity, and before he even heard the paragraph read he pronounced the whole story to be only an invention to fill up the newspapers. After he had relieved himself and subsided into silence, I went on to read about this peculiar kind of a clock, which was described as being moved by electricity. Telegraph wires connected the two cities, and the vibrations of a pendulum in one city were made to close the electrical circuit momentarily, and, through the agency of an electro magnet, a soft iron armature was attracted at stated intervals, and by this means the hands of the clock were moved in the other city, forty five miles distant.

In the course of a few weeks after this, "Our Maister" intimated his intention of making an electric clock, but "our journeyman" ridiculed the proposed innovation in our business, and prophesied that a complete failure would be the only result. "Our Maister" was not a man that was frightened by any croaking of this kind. When he had made up his mind to do anything he generally did it; and after communicating with some friends who knew something about the workings of the electric telegraph, and advising with others who had studied the subject of electricity, he commenced making his clock, which he intended, when finished, to stand on the end of the show-case on the counter, and be covered with a glass shade, so that the working of all the mechanism could be easily seen. He decided to make the clock on the plan of those electric clocks now known as secondary dials. It only contained one wheel between the frames which had ratchet-shaped teeth cut in it. There was an electro magnet fastened on the frame in a convenient position, made from a piece of soft, round iron about half an inch in diameter, bent nearly in the shape of a horseshoe, and the two ends filed flat. This bent piece of iron was between two and three inches long, and round its two legs was wound a quantity of small copper wire smeared over with sealing-wax, and the ends of the iron that protruded

through these coils of wire and sealing-wax he called the poles of the magnet. Then there was a piece of soft, flat iron of an oblong shape which he called an armature, and which was fastened on the end of a short brass lever, which was attached to an arbor pivoted into a frame, and arranged so that the armature would stand exactly before the poles of the electro magnet, and be attracted by it when the power of attraction was in the magnet; and there was also a spring which pulled the armature back a short distance from the poles of the electro magnet when it lost its magnetic power. Attached to the armature there was another short arm which had a click fastened to it. This click worked into the wheel with the ratchet-shaped teeth previously mentioned, and every motion of the armature turned the wheel round one tooth, while another click prevented it from turning more than one tooth at a time. There were sixty teeth in the wheel, consequently each tooth represented a minute. The minute-hand was fastened to the end of the axis of this wheel, and, of course, there were the usual motion wheels for the hour-hand.

After the movement was completed, a battery had to be made. This battery was constructed in the simplest manner in which a Daniels battery can be made. It consisted of a water-tight copper vessel, in the centre of which stood the porous cup, and in the inside of this cup was placed a piece of zinc of a shape that would present the greatest amount of surface to the action of the liquid that surrounded it. The porous cup was filled with water mixed with a few drops of sulphuric acid; the copper vessel was also filled with water, and a small quantity of sulphate of copper being added, completed the battery. A wire was attached to the copper vessel and one to the piece of zinc, and when their ends were connected the chemical action took place among the elements which composed the battery, and electricity was produced; and when the two ends of the wire were not in contact, there was no chemical action in the battery, and consequently there was no electricity generated; no matter how long or how short the wires were, the effect was the same.

The next thing that had to be done was to construct some mechanical arrangement and attach it to a clock in such a manner that at the end of every minute the two ends of the wires would be connected for an instant. This was accomplished by fastening a plain wheel, with a notch cut in it, on to the scape-wheel pinion, and isolated from the steel by a collar of ivory. A small steel spring, shaped somewhat like a Swiss ratchet click, was fastened to a piece of ivory placed between the clock frames. One end of the spring rested on the plain wheel on the scape-wheel arbor, and at every revolution of the scape-wheel this spring would drop into the notch and would immediately be lifted out again as the scape-wheel revolved. One of the wires leading from the battery was fastened to this spring, and in a convenient place in the spring a small piece of platina was fixed, which was in reality the end of this wire. The other wire leading from the battery was led directly to the magnet of the electric clock, or secondary dial, and fastened to one of its coils. Another wire was attached to the other coil of the magnet and led back to the clock that was designed to close the electrical circuit, and the wire fastened to another piece of platina fixed to the ivory before mentioned and near to the first piece of platina, and this platina was also the end of the second wire leading from the battery. The action of the clock and battery was as follows: When the scape-wheel of the clock which closed the circuit turned round, the spring fell into the notch cut on the edge of the plain wheel fastened on to the scape-wheel arbor, and the two pieces of platina were momentarily brought into contact with each other, the electric circuit was closed, chemical action commenced in the battery, electricity was generated which pervaded the entire length of the wires and gave power to the electro-magnet, which immediately attracted the soft iron armature placed before it. The next vibration of the pendulum allowed the scape-wheel to move forward another tooth, the spring was lifted up out of the notch, the two pieces of platina were separated, chemical action in the battery ceased, there was no electricity in the wires, the electro magnet for a time lost its power, a spring pulled the armature back from the poles of the magnet to its original position, and the hands of the electrical clock were moved forward one minute.

The progress in making the clock was very

slow. Being a new thing, "Our Maister" had to study a great deal on it, and many alterations had to be made. "Our journeyman" did not believe in this manner of making clocks at all, and when this one commenced to take its final shape, he said the more that he saw of it the more he was disgusted, and his disgust was all because there were so few wheels, no escapement, and no pendulum to the clock. How could it be possible, he argued, for a clock to go and tell the time with so few wheels, and especially without an escapement. He seemed to think that there was some mysterious property inherent to wheels and escapements which, in themselves, caused watches and clocks to run regular; but, as for me, with the unsophisticated innocence I was possessed of at that time, I thought a few wheels less, or even the absence of an escapement, was of little consequence; and so far as I was concerned, I did not care, although the entire works were done away with; at least the pins, screws, and all parts that I had anything to do with making.

When the clock was completed, it could not at first be made to go at all, and every attempt to set it in motion was fruitless. "Our journeyman" was sure that this would be the inevitable result, and thought himself to be very wise in predicting it from the beginning. Now there is nothing easier in this world than to prophesy the failure of an enterprise; and to do so it is not always necessary either that one should understand anything about the scheme he distrusts so much. If the enterprise does fail, of course he naturally gets the credit of a more profound knowledge of the thing than he is entitled to; and if it succeeds, he was only a little mistaken. The new electric clock could not be made to move, or life put into it by any means. "Our Maister" was silent and moody, and appeared to be a little crestfallen, while "our journeyman" was a little more noisy than usual, and advised that this nonsensical kind of a clock should at once be consigned to the brass-founder's melting-pot, and no more time lost with it. Matters continued in this condition for a number of weeks, when the tables were turned. It was discovered that the wires wrapped round the electro magnet were in some instances touching each other, whereas it was necessary that they should be perfectly insulated This defect was remedied, and life then appeared in the clock at irregular intervals, and after the armature spring had been adjusted, and other vital points slightly corrected, the hands of our new electric clock commenced to move and to follow those of the standard clock with the greatest amount of precision and regularity. At first we looked at it through the glass cover; all of us would start back involuntarily when we saw the armature and the hands move without any visible cause, and "our journeyman" was utterly confounded, and appeared as if he thought that his Satanic Majesty had come to the rescue.

One day a customer called to see the clock. He was pleased with the simplicity of its arrangement, and its apparently regular action, but expressed his opinion to "our journeyman," who waited upon him, that it would be liable to be influenced by a thunder-storm. He said that thunder-storms had been found to interfere with the working of the electric telegraph, and he had lately read in a newspaper about a telegraph operator who had been seriously injured during a thunder-storm while standing near his instrument. Now this was a piece of news which exactly suited "our journeyman" and his prejudices, and he was greatly delighted that at last he had found a strong argument against the reliability of electric clocks, and their positive danger to human life during the progress of a thunder-storm. "Our Maister," who was greatly elated with the success of his experiment, scouted the idea of any danger from that source, and laughed at every proposal made by "our journeyman" to have the thing removed to a place of safety. A short time after this "our journeyman" and myself were left in charge of the shop, and during the time a terrible thunder-storm broke over the town, and the lightning was either terrible or magnificent, just as different people regard lightning in thunder-storms. "Our journeyman" looked at the electric clock and rose up from his bench and went into an apartment at the rear of the shop and shouted to me to follow him, but I remained at my work and would not move; not that I was more courageous or more devoted to duty than he was, but it was a blissful state of ignorance of danger that made me stay; while he, with a little knowledge of the possibility of danger, got into a terrible state of excitement, and expected every minute to see the

whole building blown up. I suggested to him the propriety of gathering his tools together and save them and himself by going home; but it was raining torrents outside and he could not allow himself to get wet; so, standing between two dangers, he at last shut the door of the apartment he took refuge in and looked through the keyhole, momentarily expecting the explosion to take place. After a time the thunder-storm passed away and no damage was done, and the little innocent electric clock continued to show correct time as usual. When the "Maister" came home, "our journeyman" told him plainly that unless the electric clock was removed to a place of safety, that he could not continue to work in the shop any longer; but "Our Maister" looked at him as if he regarded him as a lunatic. "Why," says he, "you are as bad as the old women who think gas meters are placed in cellars that they may be less dangerous should they happen to explode. What connection has my clock with thunder-storms? The wires do not go outside the building, and they are as harmless as the wires of my door bell; and if they did require to be placed in the open air I could use insulated wire, which would protect them from the influence of atmospheric electricity, and in the battery connected with the clock there is not as much electricity generated as would kill a house-fly." "Our journeyman" was perfectly satisfied with the explanation, and we heard no more about the danger of electric clocks during thunder-storms.

Although "our journeyman" was appeased on the danger of thunder-storms and atmospheric electricty affecting the clock, he still retained a bitter prejudice against it. He could not openly condemn it now, for there the clock was, performing satisfactorily before his eyes; but if he waited on any customer that appeared any way sceptical concerning it, he would embrace the opportunity to pucker up his lips and make his face into that shape which he considered would betray the greatest amount of scientific knowledge, and remark that he was afraid the electricity would magnetize the works in a short time. It happened, however, that what works there were in the clock were nearly all brass, and beyond the influence of either electricity or magnetism; but this little circumstance did not prevent "our journeyman" from expressing his views on the subject, and many people of our town thought that he should know all about it, after having had two years' experience in London. There was something truly fascinating in looking at this clock and seeing the magnet work and the hands move without any apparent cause. It was also curious to notice the remarks different people made about it. There was one old gentleman, a noted character about our town, who had many eccentric ways about him. He was a regular visitor to our shop, and one afternoon he was earnestly engaged watching the electric clock, when the parish minister came in, and after a few words of conversation, he asked him what he thought of the new kind of clock. "Oh, sir," he replied, with the greatest amount of fervor, "I just think that God has kept nothing from man that He knows himself."*

The last time we visited that quarter, the electric clock, although a primitive construction, was still in motion, but its novelty had entirely passed away. During the past few years these clocks have been greatly improved, and while we would freely bestow all credit and praise upon those who have brought them to their present state of perfection, we must not forget that much of the success attained at the present day is due to the experience that has been derived from the labors of such men as "Our Maister" and his contemporaries.

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Watch Repairing.—No. 5.

BY JAMES FRICKER, AMERICUS, GA.

We will again take up the fuzee and its "belongings" in this article.

It frequently happens that the square of the fuzee has become so worn that either a new square or a new fuzee must be put in; and of course, in this case, the best plan is to put in a new one. Select one of the proper size and thickness, being careful to see that it will give the chain the proper number of turns, and the groove all perfect, and of the proper width for the chain. Put a brass chuck about an inch long in the lathe, make a deep centre in the end of it, heat it with the lamp until it is hot

* A remark made in the writer's hearing.

enough to melt shellac, then apply plenty of it to the end of the chuck, holding the lamp so that the flame will strike the chuck and the cement at the same time; warm the fuzee, and place the lower pivot in the cement and true it up by the upper pivot. If the watch is a plain one—that is, not jewelled—broach out the old hole just sufficient to make the hole round, then polish it with a round broach. If the fuzee hole is jewelled, examine it to see if it is well polished; if it is not, it must be polished with diamond powder or tripoli, directions for which will be given when we come to speak of jewelling.

Now turn down the pivot so that it will almost enter the hole, leaving the shoulder the same height above the body of the snail as the old one. Turn out the hollow and mark on the pivot with the graver, by turning out a small groove for the bottom of the square, and make a good centre on the end of it. It is now ready for the grinding process. First, grind out the hollow with oil-stone powder and oil on the end of a nail filed up the proper shape, using considerable pressure, and file up the end of the nail frequently, as it soon wears smooth. The oil-stone only cuts the steel, while the grinder is rough. I say use a nail, from the fact that iron is better for this purpose than steel, and nails are always to be had, and are of about the right length and size—say an 8 or 10 penny. Continue grinding until every sign of the graver is removed, then with a steel polisher, such as described in the last article, grind the pivot so that it will enter the hole easily, bearing in mind that it must be turned so near the size wanted as to require only just sufficient grinding to eliminate the marks of the graver. Carefully clean off every particle of oil-stone powder, and for this purpose nothing is better than fresh, soft, light bread, which should be worked with the fingers so as to make it more compact than when just taken from the loaf; this is what is used by all jewel-makers and "finishers." (A "finisher" is one who fits and polishes up all the steel work in hand-made chronometers and watches.) If bread is not convenient, use alcohol and a brush, then pith.

Next use from two to three different grades of crocus or rouge, on bell metal polishers, shaped like the iron and steel ones, cleaning off every particle of the coarser grades of each before applying the finer one. It will take some time and considerable pressure to bring up the "hollow" so as to produce that beautiful *black* polish usually seen on the steel work of fine English watches. Lastly, use Vienna lime and alcohol on boxwood. The upper pivot proper, shoulder and hollow, being finished, take the fuzee down and again cement it up in the lathe, this time with the lower pivot out.

Get the length of arbor and pivot from the old one, turn down the arbor to fit the hole in the main wheel, and the pivot to fit its hole, leaving just sufficient excess of metal to enable you to grind and polish out all the marks made with the graver, and make the pivot the proper length and finish up the end of it. Now, while it is still up in the lathe, put on the main and maintaining wheels and washer, crowd them up close to the fuzee, and with a sharp-pointed graver mark on the fuzee arbor, through the hole in the washer, for the pin while the lathe is running. Take them off and take down the fuzee, select a brass ratchet of the proper size and fit it to the fuzee arbor as described in the last article. Before putting the fuzee back in the lathe again, drill a hole in its arbor for the pin, using a very hard drill, to make which, either turn (the best way), or file up a piece of steel wire to the proper size. If turned up in your lathe, give it a slight taper back from the point, leaving the end just the right size; if filed up, make it a little smaller than the hole is intended to be, and then spread the end of it a little with the hammer, filing both sides flat and slightly tapering towards the point, and making the end the proper shape, only leaving it somewhat thicker than is needed, hardening it in oil or water, and brightening with emery; then take the drill by its extreme point with a pair of plyers or tweezers and carefully draw the temper from the body of the drill until brought down to a blue. The part immediately in front of the plyers will be a straw color, and the extreme point and cutting edges will not be "drawn" at all. With such a drill you can easily drill a hole through a fuzee arbor, not crowding it too much, or the end will crumble off. Before commencing to drill, sharpen the drill on an oil-stone and reduce the end to a proper thickness. In heating steel red hot you are apt to burn the extreme outer surface more or less, and for that reason, always leave any

cutting tool slightly thicker or larger than wanted, so as to be ground down to the proper size. Having drilled this hole and riveted on your brass ratchet, again cement the fuzee up in the lathe and finish the ratchet, as directed in article No. 4, then take it down and file up the square to a proper size. In doing this it is usual to take the chuck out of the lathe while the fuzee is cemented on the end of it, which enables us to hold it better than we otherwise could, or else we file it up before finishing the lower pivot, in which case it can be held in the pin vice; lay the upper pivot on the file block and flatten one side with a file, filing down to the groove cut for a guide; turn it over and file the opposite side, getting these two sides parallel, then file up the other two sides in like manner. Next grind each side with oil-stone powder and oil on a steel grinder, and finish up as directed in article No. 4, cutting off the fuzee square to a proper length, and finishing up the end as directed in the same article.

It sometimes happens that you have no fuzees in stock, and that your customer can not wait until you can send to your material dealer for a new one, in which case you must turn him away or else put in a new arbor. It is useless to attempt to put a new square on the old one, as it would soon get loose. You can make a good job by putting in a new arbor, although it is more work and takes longer to do it than to put in a new fuzee. Put the old fuzee up in the lathe, upper pivot out, and with a sharp-pointed graver cut through the snail just far enough from the arbor to clear it; take it out of the lathe, place it on a hollow stake, and with a hammer drive out the old arbor, cement the fuzee up on a chuck, the face of which is as large or larger than the fuzee, true it up and bore out the hole very slightly, and make a shoulder in the upper part, but not very deep; next turn down a piece of steel wire to fit the hole in the fuzee very tight, leaving a shoulder on it to correspond with the shoulder in the fuzee; next turn down for the lower part of the arbor and pivot, leaving it a little larger than is needed. You can also shape the other end without removing it from the lathe, cutting it off, and making a good centre on the end cut off, and centring the lower pivot before it is cut off. If you are careful and get the measurements properly, it is easy to drill for the pin while it is soft, otherwise you can wait until after you have put it in the fuzee. File up the square while it is soft, then harden in oil or water, brighten with emery, and draw it down to a blue; apply some soft-soldering solution to the arbor where it is to fit in the brass, drive it to its place in the fuzee, and apply some soft solder to both sides, heating it just sufficiently to make the solder flow. If the arbor fits tight a very little solder will make it as strong as if it was riveted in. Now proceed the same as if you were putting in a new fuzee, going through all the various processes of fitting and polishing that you did in that case. I would advise this only in such cases as above indicated, and the charge should be fully as much as for putting in a new fuzee. Of course the lower hole for the fuzee pivot should be examined and treated in the same way as you did the upper hole.

The principal cause of the rapid wear of a fuzee square is from the use of the common iron keys, most of which are only square just at the end—a fact that is easily ascertained by filing off the end, when you will find that instead of a square hole you have a round one. The small silver key, with a tempered steel pipe, is the best key that has been in use for many years, but they are too expensive and but few will buy them on that account. Birch's patent key is a first-rate thing, except for extreme large or small sizes, and here again the price is an objection with the masses, although most any one who will give ten cents for a key will be willing to pay twenty-five cents, and for this price a man ought to get a *good* key; but the only kind we have been able to obtain that we could sell at that price—which by the way is a first-rate article so far as our observation goes—are those made by F. E. Allen, Keene, N. H., costing $12.50 a gross. They are about half as long as a bench key, the handle is large enough to be convenient, and each key is stamped on the end with its number or size. I think if he would bring them to the notice of the trade by advertising he would find it a paying investment.

If a new main or fuzee wheel is wanted, select one of the proper size, and to do this, a good wheel gauge should always be found on every watchmaker's bench. Put the wheel up in the lathe on a brass chuck, with cement (shellac is always meant when speaking of ce-

ment), true it up by the outside or periphery, with the lower side of the wheel against the chuck; fit the hole to the fuzee arbor and then fit on the steel maintaining wheel; next turn out the groove for the maintaining spring, reverse the wheel and turn out for the steel washer; drill the holes for the pins of the maintaining spring, filing one of them out so as to give sufficient play for the pin in the end of the spring, polish the wheel while in the lathe with Scotch stone, and then with Vienna lime, or take it off and polish it on a flat block of boxwood, using Vienna lime for the last polish.

The clicks are frequently worn or broken so that new ones have to be put in. For these use the click wire for sale by all material dealers, holding it in the pin vice and making a tit on the end of it, being careful to get a square shoulder; cut it off the proper length and finish up both sides with a fine file. The end will need a little work on it to give the proper shape to work into the ratchet, having it so that it works free and fits well in the ratchet teeth; then harden, brighten it up on all sides with emery paper, draw it down to a blue, put it in where it belongs, and rivet it in tight enough to hold, and yet have it work easy. Sometimes they are put in without being tempered, but this is only excusable in common work, if excusable at all.

We believe we have gone over about everything that a watchmaker has to do with a fuzee and its appurtenances. Any one who can do what has been explained in these articles can easily put in a new maintaining wheel, or put on a new steel washer, without any definite instructions. In the next article we shall consider the centre wheel, pinion, etc.

The Story of a Watch.

(CONCLUDED.)

I have already related how I fell into the hands of a "natural watchmaker," and how he altered all my depths, and run them so deep that there was no shake between the teeth of the wheels and the leaves of the pinions; and I have also told that afterwards a much stronger mainspring was necessary to make me run in this new condition, and how the strong mainspring broke my chain so often, which caused so much trouble and brought me into deeper disgrace. Now my depths, before this alteration, were as good as could be made. After twenty-five years of constant use they showed no signs of wear whatever, which was about as good proof as could be had that my pinions were well sized, the leaves well shaped, and also that the teeth of the wheels were of the proper form, and acted at a suitable depth on the leaves of the pinions. Of course there was a little shake between them, which was both proper and necessary; but at one time this natural genius who repaired me had something to do with some special kind of mechanism where play in the teeth of the wheels was undesirable for the purposes the mechanism was used for, and he thought that the "back lash" in the teeth of my wheels was a serious error, and that I had been made by workmen that did not know any better, and convinced my owner that this was the cause of all the irregularities that he complained of. My owner still thought that my construction had been greatly improved by this natural watchmaker, but he was dissatisfied with me on account of my chain breaking so often; and the natural watchmaker, to get rid of this difficulty, proposed to do away with my fuzee and substitute a going barrel in its place. He said that fuzee watches were played out now any way; and after complimenting my fine strong works, he said that all that was now necessary to make me a reliable watch was to put in a going barrel, and he brought out a copy of a jeweller and watchmaker's paper which had something in it that supported his opinion. My owner consented to this proposal of taking out my fuzee, and I was left to have the alterations made; but fortunately the genius was busy with other work, and could not find time to do it while my owner remained in the place, and he concluded to give me another trial as I was.

On a certain occasion my owner was sojourning in a town in Northern Ohio that bears the name of the author of the Declaration of Independence, where he was introduced to a watchmaker who had the reputation of being a very intelligent gentleman, as well as a skilful mechanic, which in reality he was. I was shown to him, and my owner related all the trouble he had to get me to run regular. "Oh," says he, "I see what is the matter; the pivot

holes all require to be inchased;" and he easily persuaded my owner to have this done, telling him of what lasting benefit it would be to me. Now this man had recently purchased a new universal lathe, which at that time was his especial hobby, and every watch that was brought to him had either to have the pivot holes inchased or some other work done to it that required the use of the new lathe. Even if only a glass was to be fitted, the bezel had to be put up in the universal lathe and the groove undercut. I got my pivot holes inchased, and, although I was not in any way damaged, the real cause of my irregularities was never looked into, and practically I was no better than before. My owner, however, had received a vast amount of information on every conceivable subject on which he chose to "start a sliver," and went away well pleased with himself and everybody else, and with the assurance that he was possessed of an excellent watch, which was now in perfect order.

One day my owner was in New York city and he took me to a place where they advised a new chain to be put in, and as large and as thick a one as my fuzee would admit of was selected and put on, and after this I continued to run for quite a long time without it breaking, but my running gave my owner no better satisfaction, for the clocks in the different towns which he visited still continued to show different time from each other, and if by accident my hands agreed with one clock it was sure to vary with the next, and I got the blame of running irregular and was regulated accordingly. During his travels my owner met with a watchmaker who said that I was not adjusted to positions; that if I was only adjusted to positions I could not help but run regular for ever after. Now this was exactly what my owner wanted, so I was adjusted to positions. The plan of obtaining this adjustment was one that is followed by some watchmakers in London, and it consisted of turning away a part of my balance staff pivots at the ends nearest to the shoulder, so that there would be a less amount of the surface of my pivots bearing upon the jewels. I do not know whether this alteration would have had the anticipated effect or not, for the very same day that my owner got me back he was jumping off his wagon and the sudden shake, which never before used to do me any harm, broke both of my altered balance staff pivots; and my beautiful balance staff, so artistically made in every particular, was replaced by another watchmaker with a piece of round steel with pivots that looked like long centres on each end of it. In this condition I continued to run, but much worse than ever I did before, and at length my owner came to the town where the "natural watchmaker" resided and I was again submitted to his tender mercies. He had made a new discovery since my owner was there before, which he was now practising extensively with great success. With reference to my fuzee he admitted that so long as my chain was not breaking, the fuzee did no harm, but he said that my "*eyesockerism*" was in bad condition; that I would have to be "*eyesockerised*," and then every thing would be right. To make a long story short, my beautiful hardened and tempered balance spring, that had its curves formed with the greatest possible amount of skill, so as to cause the long and short vibrations of the balance to be made in the same length of time, was bent and twisted about by this wretch most fearfully, and I was handed back to my owner with my balance spring completely ruined, and he cheerfully paid a large price for the supposed improvement.

In a month or so after this I stopped one day, and my next experience was with a watchmaker who said that my pivot holes were all too wide, and that I needed a new balance staff, which was all true enough, but as regarded my pivot holes he did not take the state of the depths into consideration, and although the pivot holes had been undesignedly left so wide by the "natural watchmaker," they helped me very much to run when my depths were so deep. It was very difficult to persuade my owner that these faults were in me, for he had the greatest amount of confidence in the workmanship of the "natural watchmaker" who had made some of the alterations, but after he had been shown the wide condition of the pivot holes he finally empowered the watchmaker to make whatever alterations he considered to be necessary to make me run well. Now this watchmaker put a very good new balance staff in me, and he also brushed the pivot holes, and the workmanship was very good. The pivots holes were all nicely polished, and my bent third wheel, which had been in that condition ever since I

had been cleaned preparatory to being compensated for heat and cold, was made straight. The pivot holes were very accurately fitted to the pivots, which were nicely polished, and particular attention was paid to making good countersinks to hold the oil. However, when I was set running again, the tightness of my pivot holes neutralized all the good effects of the fine workmanship, and I stopped running easier than ever I did before. My owner was again disappointed, and became thoroughly disgusted. I had cost him a large sum of money in the first instance, and he had paid nearly as much more to watchmakers for cleaning and repairing, and now having lost all hope that I could ever be made to run well, he sold me to a peddler for a mere trifle. This peddler sold me again to a second-hand dealer in watches in New York city, and I, who used to be so much praised for my good running, and considered so reliable and so trustworthy previous to being bought by my late owner, was now, from no fault of my own, completely discarded and laid aside as worthless.

After I had been in the second-hand store for a number of months, an old Englishman called one day to buy some second-hand watches. He took me up and looked at me; took me out of my case, took off my hands and dial, when he saw some private marks on my frame which showed that I was a watch that he had a hand in making when he was a young man. He immediately bought me, took me home, and at his leisure hours restored me as near to my original condition as it was possible to do, and now I can run again without the least effort on my part, and as well as the majority of the best of watches. My troubles are nearly over now, but there is one dread still haunts me that I was unconscious of in my early life, and that dread is *watchmakers.* I am about as much afraid of falling into the hands of those workmen that are possessed of only a little knowledge, which is often so dangerous, as I am of those "born watchmakers" who have been specially endowed by nature. A watch is always improved by passing through the hands of a careful and thorough workman. He often detects little faults which, although they may have no immediate influence on the running of the watch, his critically educated eye cannot allow to pass, and they are corrected, the customer being simply charged for ordinary cleaning; but a man who is full of whims concerning pivots and bushes, pitchings, escapements, etc., which have no foundation in natural philosophy, is the most dangerous of persons to repair a watch. If the watch-wearing public could only be made to understand that their watches are made much worse for passing through the hands of careless and ignorant workmen, although they may by chance run well for a time after, than they are from the ordinary wear of a lifetime, I will not consider this narrative of my life and sufferings has been written in vain.

Robert Houdin.

Whatever situation in life, under whatever circumstances, or however ignoble the cause in which it is shown, unusual talent is sure to command admiration. The successful burglar finds admirers of his misdirected talent, as appreciative and far more enthusiastic in their manifestation of it than does the inventor of the mechanical combinations which frustrate his skill in the lock-pick. The dexterous matadore is greeted with thunders of applause for the skilful thrust that sends the enraged bull reeling to his death; while the surgeon who probes a wound, extracts a ball, and saves the life of the shrieking victim of an assassin, is greeted by exclamations of horror, and his skill rewarded, perhaps, by blame for the suffering he necessarily inflicts upon the patient. The cunning prestidigitator, who so cleverly extracts a blazing pudding from an empty hat, is the recipent of golden applause; while the oculist, who dexterously removes a cataract from the crystalline lens, admitting light and joy to a sightless orb, but earns a paltry "fee." Unfortunately public admiration is not so surely awarded to those whose genius is devoted to the development of productions peculiarly useful to society, as to those who are brilliantly successful in subverting good order and honesty, or in ministering to the follies of mankind. The tendency of public appreciation is not toward a most generous reward to those who devote the highest order of talent to the beneficences of life; on the contrary, they announce the platitude that "virtue is its own reward," and con-

sequently needs no other incentive to extraordinary exertion. The instances in which this public estimation has diverted uncommon talent from useful, industrial pursuits, to those more remunerative either in wealth or fame, are numerous in the memory of all. The loss which art, science and the manufactures have suffered from this cause can never be known; and so long as uncommon manual or mental ability are better paid and better appreciated in other than useful occupations, so long will they continue to absorb the best ability.

Probably of all the millions who have heard of Robert Houdin, the greatest of mechanical "magicians," very few know of him as an expert horologist, over whose mind mechanical inspiration held such control as to force him from the profession of the law, where his father had placed him, back into his shop as a watchmaker. He says that his father's experience had proved that a fortune was rarely to be made in that occupation, for after thirty-five years' unremitting attention to business, he had hardly made provision for old age. Yet the fascinations of the profession of mechanism made the struggle a hard one between the longing of the father to make the son famous, and the desire of the son to follow his mechanical predilections. At the time this amicable contest was going on between father and son, an accident, he says, brought into the shop a mechanical curiosity in the form of a snuff-box. The top of the box represented a landscape, and on pressing a spring a hare made its appearance and went toward a tuft of grass, which it began to crop. Soon after a sportsman emerged from a thicket accompanied by a pointer. At the sight of the game the hunter stopped, shouldered his gun and fired, and the hare disappeared, apparently wounded, into the thicket pursued by the dog. This beautiful mechanism so excited his curiosity that he made drawings of the various parts without his father's knowledge, and by working upon it over hours, at last had the pleasure of showing him the completed toy; but who in undisguised admiration still insisted "that it was a pity he could not profit by his turn for mechanism."

The small provincial town failed to afford scope for the son's genius, and he soon found his way to Paris and into the shop of a relative, where his skill and diligence were appreciated. One evening, on going to a bookseller's to buy Berthoud's "Treatise on Clock Making," the tradesman, by mistake, handed him a volume which, on opening after he had arrived home, proved to be "Scientific Amusements," which detailed the way to perform tricks with cards, to cut off a pigeon's head, restore it to life, etc. The perusal of this work filled him with the idea that fame and wealth lay in that direction. In his leisure hours he diligently practised the sleight of hand tricks described in the work which chance had placed in his hand. From Paris he made an engagement with M. Noriet at Tours, who was by intuition a sculptor, and who was anxious to leave to his workmen the "shoe-black" part of the trade, and who was so fortunate as afterward to gain some distinction as a sculptor.

M. Houdin again met with one of those fatuities which so often change the current of life. Being seriously injured by the overturn of the Diligence between Tours and Blois, he was taken up in an insensible condition, and on returning to consciousness found himself an invalid in the charge of Torrini, a conjurer, who chanced to be passing at the moment with his portable theatre. This artist, a French nobleman, Count de Grisy, who had assumed the Italian name *Torrini* for certain reasons, was a most skilful performer, and, during Houdin's convalescence, a mutual friendship sprung up, which was continued to the mutual benefit of both.

His first mechanical labor while with Torrini, was the almost entire reconstruction of a mechanical harlequin, which was supposed to leap out of the box in which it was confined, perform some evolutions, and return to prison at the word of command, which labor had to be performed as the theatre was journeying from place to place. Sleight-of-hand descriptions did not satisfy his ambition; mechanical automata were still his ambition, and his search for information only brought him descriptions of mechanical toys far less ingenious than those of his own time. Search through musty volumes only brought him such knowledge as that "Albertus Magnus, at Cologne, constructed a brass man which he worked at continually for thirty years, which work was performed under various constellations, and according to the laws of perspective."

The only authentic account of these mechanisms was a description, in the Royal Academy of Sciences, of Vancauson's mechanical duck, which he afterwards saw exhibited in 1844, that drank, dabbled with its bill, eat, quacked, and digested like a living duck. This celebrated automaton afterward came into Houdin's hands for repairs, when, to his surprise, he found that the digestion so pompously announced was only a trick of juggling. A vase containing seeds steeped in water was placed before the bird; the motion of the bill in dabbling crushed them so as to facilitate their introduction into a pipe placed beneath the lower bill—the water and seed thus swallowed falling into a box under the bird's stomach. The other part of digestion was by bread crumbs, colored green, being expelled by a force pump, and being caught on a silver salver were exhibited as evidence of digestion.

Vancauson was a nobleman by birth, but, like Houdin, the taste for mechanism drove him to these constructions. Besides his flute-player, duck, and tamborine-player, he invented a chain which still bears his name, and through spite at some silk weavers of Lyons who had stoned him for attempting to simplify their looms, he constructed a loom on which a donkey worked cloth. At the time of his death, 1782, he was perfecting his endless chain, and so anxious was he for its completion that he was constantly urging his workmen not to lose a moment least he should not live long enough to explain his idea thoroughly.

Houdin's first eminent success as a mechanician was in the entire reconstruction of the musical instrument exhibited at Paris, in 1829, by a Prussian named Koppen. This "componium" was a perfect mechanical orchestra, playing operas and oratorios with the most remarkable precision and effect, and also executing charming variations without repeating itself. This instrument met with unparalleled success in Paris, and was finally taken to London at an unfortunate time, and did not prove successful. The owner had it taken to pieces, packed and reshipped to France, but owing to some informalities with the Custon House it was stopped, and before the arrangements for its release had all been completed the parts had lain a year in the damp warerooms and were but masses of rust and verdigris. Houdin says that the flattering opinion he had of his mechanical abilities led him to offer to repair this instrument. In making this offer he had two objects in view; one was to procure an interesting object of mechanical study, and another to gratify an ambition to accomplish what no other mechanician dared undertake. A mechanic will partially understand the difficulties, when it is known that he had never seen the componium in operation. The prospect was by no means cheering, when all the parts of this machine were spread out upon the floor, a perfect chaos of wheels, and levers, and pinions, and screws, and pipes, and covered with rust and dust; it would take a volume to describe all the trials, studies, failures and successes; and a whole year was consumed in solving this problem, but at last the componium arose completed.

The fame this achievement brought was not adequate compensation for the brain fever which followed this intense study and constant labor, and nearly five years elapsed before he was entirely recovered. This long illness, and the slow, wearisome progress of combining automatic movements—the countless hindrances and discomfitures that, at unexpected moments, foil the best conceived plans—wasted the small fortune he had gleaned in former years. His completed mechanical curiosities were few, and the specimens he had in hand still required years of study and labor, and the great conjurer again resumed his original trade; for while at this ordinary occupation he could meditate upon mechanical combinations. One result of these cogitations was an alarm which rang a peal at any desired hour, and at the same time a lighted candle came out of a small box. This was the first invention which brought him any profit. This alarm was so popular that he was obliged to employ several workmen, and the success encouraged him to the production of other toys—among others the "mysterious clock," with a transparent dial, which indicated the hour without any apparent mechanism. Singing birds, tight-rope dancers, the conjurer and cups were successively produced.

About this time he entered into a contract to make a life-size "writing and drawing" automaton which should answer in writing, or in emblematic designs, any questions proposed by the spectators. The price for this was

5,000 francs, the half of which was paid in advance, on the condition of its completion in eighteen months. Foreseeing that much time would be lost by "friends, customers, bores, family dinners, and evening parties," he resolved to exile himself, and rented a room at Bellville, a little out of Paris, furnished it with a bed, a few chairs, and his precious tools. Twelve weary months of laborious exile saw the automaton drawing towards completion; doubts and difficulties gradually faded away under the persistent efforts of genius, and the first question propounded to the soulless figure was, "Who is the author of your being?" "I pressed the spring," said he, "and the clock work began acting; I hardly dared breathe, through fear of disturbing its operations. The automaton bowed to me, and I could not refrain from smiling upon it as my own son. The arm, a few seconds before dumb and lifeless, began to move and trace my signature in a firm hand writing. The tears started to my eyes, and I fervently thanked Heaven for granting me such success."

Following this was his mechanical nightingale, and other less notable productions, with which he made successive tours through all the principal countries of Europe. On exhibiting his mechanical productions at the Exposition in 1844, one of the Jurors expressed the regret that Mons. Houdin did not apply his talent to serious labors instead of fancy objects. In his memoir Houdin says: "This criticism wounded me the more, because at this period I considered nothing superior to my works, and in my fairest dreams of the future I desired no greater glory than that attained by the skilful inventor of the automaton duck. 'Sir,' I replied, in a tone that betrayed my pique, 'I know no works more serious than those that give a man an honest livelihood. At the period when I devoted myself to chronometers I hardly earned enough to live upon; at present I have four workmen assisting me, the least skilful of whom earns six francs a day; ought I therefore to return to my old trade?'" The jury granted him a silver medal for Automata. During the succeeding ten years Mons. Houdin devoted much time and study to the application of electricity to mechanisms, and a lingering love for his early profession gave to those studies such a *chronometro-electrical* direction that he adopted the motto, "*To popularize electric clocks by making them as simple and exact as possible.*" And he says, he "dreamed of the day when the electric wires, issuing from a single regulator, will radiate through the whole of France and bear the precise time to the largest towns and the most modest villages." This dream now bids fair to be soon realized. At the Universal Exhibition of 1855 he received a medal of the first class for new electrical applications.

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Mechanical and Metallurgic Operations in the Bank of England.

The *Quarterly Journal of Science* contains an interesting article on the practices in the Bank of England, a synopsis of which may not be devoid of interest to readers of the JOURNAL. Coin may be regarded as one of the products of the highest development of mechanical and metallurgic science. Positive exactness in weight,—produced by the action of the finest machines, determined to almost an absurd minuteness by balances that cannot be surpassed for delicacy of indication, and the quality of the composition carefully tested by a system of assays which are the practical result of the highest chemical knowledge,—these combine in all the necessary operations to produce a coin (sovereign) which shall weigh within 1:6 in a thousand, 123.27447 grains, and which must contain $\frac{916.666}{1000}$ fine gold and $\frac{83.334}{1000}$ of copper. The perfection of modern machinery confines the products within the prescribed limits in a wonderful degree, and the tabular report of assays, from time to time, of coin taken at random from large masses, do not vary $\frac{2}{1000}$ from the legal standard. The commercial regulations of the Bank require them to take from any one gold of the standard fineness and to return to them the same weight in coin. The gold so "imported," as it is technically called, must be accompanied by a "trade assay report" stating its degree of purity, and the importer or his agent must be present with an officer of the Mint to witness its correct weight. The bullion is then assayed at the Mint, and if the importer makes no objection to the results of the assay, it is melted with the proper proportion of alloy, and then coined.

Practically the Bank of England is the only importer of bullion, because the owners of ingots can readily realize the value of it by selling it at once to the Bank, and thus save the time necessarily consumed in coining. Besides, if bought by the Bank, the notes can be taken away in a purse, but to carry the coin may require a sack. The law compels the Bank to purchase ingots at £3 17s. 9d. the ounce, which is three half-pence less than its value in coin, and this three half-pence gives the Bank a profit of £2,000 on each million.

From reliable bankers of unquestionable reputation, the Bank receives gold ingots weighing 200 ounces, bearing the brand of the banker presenting it. The mechanical operations of the Mint are, first to melt the ingots in crucibles of a mixture of blacklead and Stourbridge clay, 9¼ inches deep and 7 inches interior diameter, and about 1,200 ounces are sufficient for one melt. A cover is luted on the crucible, through which is a funnel-shaped opening, which are placed in the furnace and surrounded with fuel. When red hot the ingots are added and the fire increased till they are melted. The alloy necessary is then added through the funnel and the foreman agitates the mass with a rod of plumbago and clay till he *feels* that it has reached the proper degree of viscosity to work under the rolls. The melting pots are then raised from the fire and the precious contents cast into bars 24 inches long, 1.375 inches broad, and ½ inch thick. These bars, containing above 180 ounces Troy, are assayed to verify their composition, then go to the rolling mill and are reduced to a ribbon nearly of the proper thickness, and cut into lengths of 20 inches. The rolling so compresses and hardens the metal that it must be annealed, which is done by placing these strips in a copper tube, the open end luted with clay, and subject to a red heat in a muffle for about 20 minutes, and are then plunged into cold water and rapidly cooled. This method of annealing prevents the oxidation of the copper, and makes the strips soft enough to permit their being drawn through a fixed orifice to produce a positively uniform thickness. From these strips the coin blanks are then punched, and the waste sent back to be again melted. These blanks are then "rung" by boys, to ascertain whether there exist any flaws, which sometimes occur by air bubbles being caught in the cast ingot and rolled out with the plate. The sound blanks are then placed in copper tubes, the ends luted as before, and annealed in the reverberatory furnace, quenched in cold water, dried off in sawdust, and sent to the coining press. One blow gives the effigy upon both sides, and mills the edges.

One of the most ingenious automatic machines is for determining light, heavy, and medium coin, and at the same time depositing each in a separate receptacle. During all these processes the most rigid system of inspection of size, weight, and composition, is maintained, as each coin must conform to the law in all these particulars. Notwithstanding all the careful scrutiny which the highest skill can bestow, it occasionally happens that the gold will prove brittle to such a degree as to interfere with its successful working. This difficulty is generally due to minute quantities of lead, antimony, arsenic, or bismuth. The addition to fine gold of 0.05 per cent. of antimony, and arsenic equal to 0.1, will destroy its ductility. The most simple and efficient remedy for this is the method now universally adopted, of sending through the molten mass a stream of chlorine gas. This forms, with the baser metals, chlorides, which are volatilized by the heat and pass away in vapor. Only three to four minutes are required for their elimination, leaving the mass entirely free and perfectly malleable. The noisy old atmospheric presses of Watt & Boulton are still in use, and that they are efficient is shown by the quality of work they do; but they must ere long give place to more modern machinery. At the present time the control of the British Mint devolves upon the Chancellor of the Exchequer, who appoints the chemist and other operative officers. The uniformity of the British coin attests the capability and fidelity of the Mint officials.

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Corals.—We have already spoken at length on this subject, giving a description of the method of obtaining the coral, as well as manufacture; but only by actual inspection can one realize into what exquisitely beautiful forms this material can be wrought. Mr. Andrea Errico, No. 19 John Street, has recently added to his stock some of the most beautiful specimens ever imported into this country.

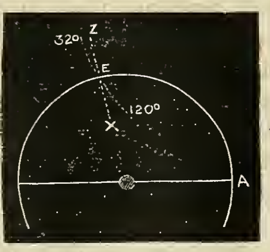
Overton's Compensation Balance.

In the May number of the *British Horological Journal*, Mr. John Overton thus describes his Geometrical Compensation Balance, with which he proposes to overcome the necessity of auxiliary compensation :—

Some time since, I was about to write an account of chronometer balances, and had part prepared the necessary drawings, but just at that time I came to the conclusion (from reading the *Horological Journal*), that a perfect compensation balance had been contrived by better and abler hands than mine. However, a few days since, while studying the tables on rating, I was much struck with the number of chronometers that had auxiliary compensations, and the use of these proved to me that a perfect balance was still wanting. By a perfect compensating balance I mean one that shall require no auxiliary, yet shall be comparatively easy of adjustment to the various temperatures; a balance, in short, in which the main weights shall move in a constantly and uniformly decreasing ratio as the temperature changes from 120° to 32° ; and, on the contrary, shall move in a constantly increasing ratio while the temperature changes from 32° to 120°.

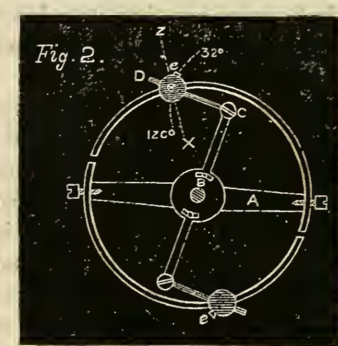
In order to make myself perfectly understood, I must claim the patience of scientific readers, while I recall to their minds the causes of error in the balance which have led to the use of auxiliary compensations.

In diagram No. 1, A represents the ordinary

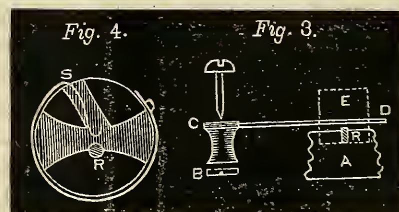


balance, E the weight, X Z the line oi centres. The curved line is an approximation to the direction in which the weights will move under change of temperature. In passing from E to 32° it runs directly parallel to the line of centres; but from E to 120° it is divergent. (And let it be borne in mind that this curve will vary in different balances according to the expansibility of the metals employed, and thus make it difficult to apply the auxiliary with any certainty of its action.) Now we have merely to change this divergence from the inside of the balance to the outside and make the weights to move in a proper curve, and we have no further use for an auxiliary compensation.

The way in which I propose to do this will be understood from diagram No. 2. Let A be



the ordinary compensation balance with two small circular slots in the bar just outside the staff collet, as shown by the dotted lines at B. B C is a loose steel bar, fitted friction-tight on the staff-collet, and fastened to the balance by two small screws passing through the slots in the balance bar, the ends of the taps showing at B. C D is a lever rod working freely without side shake on a screw at C, on which the weight E is firmly screwed, the side of the rod near the screw *e* being slightly flattened to insure parallelism in moving the weights on the rod, in order to obtain the right curve. Diagram 3 is a side view of the rod, with a section of the bar B, weight E, and rim of the balance A. Diagram 4 is an enlarged view on the underside of the weight E. R is a ruby pin sunk into the weight and the side laid bare in the groove that fits over the balance rim, as shown in Figures 3 and 4. S is a spring screwed



to the weight and bent around and under it as may be found most convenient. The action is this :—the balance rim is gripped between the ruby pin and spring, and, consequently, the

weight moves with it as formerly, but in the curve as controlled by the lever C D. The slots in the bar of the balance permit the bar and weights to be moved for the main adjustment; and, as I said before, the curve they are made to take will supersede the necessity for an auxiliary adjustment. In making the drawing I have merely striven to clearly illustrate the principle, but in practice it might be found better to continue the bar B as far as possible without actual contact with the balance rim, as by that means you obtain a better set of curves and the lever is more nearly concentric.

If any one should think well to apply a balance of this construction, and should place it upon trial, perhaps they would kindly describe it as the geometrical balance, that I may be able to compare its performance with others.

John Overton.

Percy St., Coventry, Feb. 12th, 1872.

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Temperature Experiments.

We beg leave to direct the special attention of the readers of the Journal to the experiments at present in progress to determine the average temperature of the atmosphere of those apartments fine clocks are usually placed in. We know that a number of our readers are engaged in making such experiments, but in order that they may be as varied as possible, and that the controversy on the subject should be satisfactorily settled, we call upon every reader of the Journal to try the experiment for a few weeks under the special circumstances in which his clock may be surrounded. It is not necessary that the experiment be tried on a fine clock; any clock having a long case will be suitable, and when convenient the two thermometers should be suspended in the inside of the case; but when that cannot be done easily, the outside will do. All that is desired is to know the difference in the temperature of the atmosphere at each end of the pendulum, and without any regard to the regular running of the clock. It is proposed that the thermometers be compared three times a day,—as early in the morning as possible, at noon, and as late in the evening as may be convenient.

The results obtained are requested to be sent to the Office of the Journal about the end of January, accompanied by such explanations regarding the method by which the room was heated and ventilated, the size of the room, and the height of the ceiling, and such remarks as may be considered necessary to give the reader a clear idea of the circumstances under which the experiment was tried.

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American Institute Fair.

It is much to be regretted that, with the abundant material in this city, there should be so very slight a display in the Horological Department of the Fair. Of the Watch Factories, only two are represented—the United States and the American. The United States Watch Company, in addition to their former display of finished work and the parts of a watch in every stage of completion, exhibit models of the new $\frac{3}{4}$-plate movements soon to be introduced to the trade—a description of which we shall give hereafter. The American Watch Company are represented by Howard & Co., exhibiting every variety of movement and style of case manufactured at Waltham.

Messrs. Autenrieth & Himmer, 371 Pearl street, New York, Factory Long Island City, make a fine display of electric clocks of the special construction they have lately patented. In addition to a number of clocks suitable for the parlor or business office, they exhibit three fine regulators, constructed on the same plan as their electric clock described in the August number of the Journal. They also exhibit two secondary dials, one twenty inches in diameter, and the other six feet. The mechanism that works the hands of the six-foot dial is no larger or stronger than an ordinary French clock. As the construction of the mechanism of Mr. Himmer's secondary dials contains some features of special merit, we propose to give a drawing and a detailed description of it in the next number of the Journal.

The manufacture of clocks is one of the most important branches of the mechanic arts in this country, but none of the numerous clock companies make an exhibition of their goods. We are at a loss to account for the slight inter-

est manifested by the manufacturers of Horological instruments, but such is the fact.

Adams, Hallock & Co. make a fine display of their goods, the Cryptochylon Ice Pitcher, and Communion Service; but the general exhibition of plated ware is much less than usual.

The Kings County Exhibition, (the first) held in the Brooklyn Rink, make a very fine show of the industrial pursuits of Brooklyn. It could not be expected there would be much in the Horological department, as it was purely a local affair. The different manufacturers of plated ware were represented. The Webster Manufacturing Co., the Wilcox Silver Plate Co., W. J. Miller, and the Manhattan Co., all make fine displays. The only specialty in that line is the Coffee Percolator of the Manhattan Plate Co.

Mr. Bell's Experiences.

Mr. J. W. Bell, in speaking of his experience in adjusting, says that a lot of movements had been put up in the grey. On examination the mainsprings were found to be rusty, and they were ordered to be sprung over. On putting in new hair-springs the adjustment for temperature was found to be not in the slightest degree disturbed, proving that changing the hair-spring did not affect the adjustment in the least. Again, in adjusting balances to temperature he found that, by placing the screws in certain holes, the adjustment was nearly correct; and that by ordering the balance-maker to thus place the screws, they all come to his hand almost perfect, and they could be sprung and timed at once with but little further attention. He has also repeatedly adjusted a watch to temperature, and then removed a full turn of the hair-spring, and yet the adjustment remained undisturbed, showing that the shortening of the hair-spring an inch had not affected the compensation, although the rate, of course, was greatly accelerated. Have any of the readers of the Journal had similar experience?

Mr. Bell's experience, as above, was in the adjusting department of an American Watch Factory, and of course the springs and balances were more uniform than would be the case with material used in ordinary repairing.

Reply to R. C.

Ed. Horological Journal:

Your correspondent R. C., in the October number of the Horological Journal, shall have his wish granted, less the description of the mechanism, which I do not as yet consider perfect enough for publication. The difficulties apparent in complicated schemes only strike us when we look at them as a whole. When they can be pulled to pieces they lose their formidable character. The external motions to which watches are subjected when worn in our pockets on all occasions, must be divided or separated into classes; as, for instance, a motion purely circular is one, while *perfect exemption from* circular influences is another and very different class in its effect on the rate of a watch; especially where the balance staff is short, as in full-plate watches, per same thickness of movement as the three-quarter plate ones.

It is easy to make a machine for *only one class* of motions or shakes. It is only necessary that the motion of the pocket does not perceptibly accelerate. Second, that the watch which is to be tested is not shaken *more* than in the natural (man's) pocket. Third, that watches with the chronometer escapement are never shaken circularly, no matter how *small the shakes* may be, especially when the machine has the same number of vibrations per second as the watch has, because the motions or vibrations of the machine (I use this word often, to make the thing simpler and easier understood, tautology or not) are regular, and not as in the natural pocket, namely, often broken, and their direction changed. Fourth, that the watch to be tried remains as long in the automaton as usually in the pocket, say from twelve to eighteen hours at a time.

Although a separate contrivance for each class of such external motions as we may choose to interest ourselves in, may be expensive to the general watchmaker, yet, where many watches have to be tested at the same time, one machine answers for them all, if it is made large enough.

The advantage over nature comes from the power of isolation, as for instance a man wished to know the effect a certain class of shakes, not in the least adulterated with other classes (that he may understand the cause if his watch

varies therein), he could not find it out in the usual way by any means that he might adopt; he had to make a device of some kind that produced the motions which he wanted; we all are obliged to see this. If we do not care *what our watches do* under certain circumstances, that is quite another thing, and one that my theory does not reach; but we must not expect to compete with the parties who *might care*.

Having now corrected the effect of a particular class of shakes, we can only undertake another class by making another contrivance, and one that may be as different from the previous machine as the pendulum is from the balance and spring.

The two classes above explained are *simple* classes; or, effects that have only one cause to each of them. This article, therefore, only refers to two simple classes of external motions that can only be had perfect and pure by artificial means. Every *compound* class has *two causes* of variation, and *one effect;* the latter is the same as in a simple class where only *one* cause of error is a controlling agent. The effect of a compound class is very eccentric, because it is produced by two causes, as before stated, which sometimes counteract, and even occasionally neutralize each other; and, in the latter case, no effect whatever is produced, so far as external motion is concerned; but when the two causes act in concert, the effect on the rate of the watch is the same as in simple classes (the two causes in a compound class have only the *same* power as the "one" cause in the simple class; and *then* they must act or pull together). All that is said about "compound classes," in this article, is diversion; but I will make a few remarks to show what a complicated thing the motion of the natural pocket is, as regards its effect on a watch balance. Thus the two causes in a compound class differ so much in power at times, according to circumstances that cannot be gone into here, that one may be represented by 99, and the other by 1; when they are balanced they are 50 each; while the cause in the simple class is 100 in power, and never alters as long as the class remains non-adulterated. It will be seen that the compound merges into the simple—99 is near it; but as long as 100 is not reached, the class must be known by the name "compound." Next prepare for another curious fact: there are two forms of the compound; and one of them, you can imagine, is made by working the two separated simple classes of this article by *one* machine instead of *two;* nature can do this; but nature cannot make the "simple shakes," and here is where we can get ahead of her, nice enough.

While I am speaking of these things, and have given directions, R. C. may have more experience in these things than I have had, from the fact that he considered it worth mentioning. I never could get pocket chronometer makers interested in so apparently novel a thing as wearing delicate pocket chronometers by steam power. J. MUMA.

Hanover, Pa.

The Friction Question in a Fog.

ED. HOROLOGICAL JOURNAL:

I have been a constant reader of the JOURNAL since the issue of its first number, and I am sure that you must be congratulated on your successful efforts in catering for the Horological public and laying before them, from month to month, a liberal supply of Horological literature, fresh and sparkling, embracing much that is scientific and practical and occasionally a little humorous. I consider the communication of Mr. Muma, in your last issue, eclipses the best efforts of your usual contributors, containing, as it does, within one single communication a few plain practical hints, much of the scientific and incomprehensible, not a little of the sublime, and also a little sprinkling of that quality that is needless for me to mention, seeing that it is so close a neighbor to the sublime.

Mr. Muma tells us that "all that man can do in his best direction is to approach the ideal," and this is a self-evident truth which those who appear to Mr. Muma as tempting Providence would do well to consider a little more particularly. "The trouble with us all is, not enough of thought at one and the same time." What does friend "Clyde" think of being called an outsider in the friction controversy, siding with the stronger party? This is a short way of getting rid of the arguments of "Clyde," but what will he say when he

hears "that the laws of nature cannot always be followed with advantage?" Mr. Muma's remarks on the influence of oil on pivots show a little blue sky through the cloudy atmosphere, and it would be well for those in favor of the idea that friction is independent of the extent of the surfaces in contact, to consider it well, and see if this is not the key to the whole controversy, so far as it relates to watch balance pivots.

The description of the opposing forces which come into action in a watch as is described by the two ghosts "squeaking in their lank witches (languages), and worse dial acts (dialects) and struggling to get the ascendancy over each other," representing the "antithesis of what is known as acceleration," is one of the most unique illustrations in the annals of Horological literature. I have always had an idea that, practically, acceleration in a new watch lay in a great measure, if not entirely, in the balance spring. Mr. Muma, however, presents another theory, and one connected with friction too. I hope that on some early occasion we will hear more from Mr. Muma on this point, for he is certainly possessed of some original notions concerning the cause of errors in watches, which evidently are the result of much study of the various forces which impel and control the motions of a watch.

Boston, Mass. J. C.

—o—

"A Standard Ring Scale."

Ed. Horological Journal:

I notice an article with the above caption signed "B. F. H." in the September number of the Journal, and I think the trade generally will agree with him as to the great necessity of having some standard ring gauge—one that can so endorsed by the trade generally—the same as Dennison's mainspring gauge is now. The flat gauge suggested by "B. F. H." I consider objectionable from the fact that, unless a ring is very thick, it will, in the hands of one person indicate a different size from what it would in the hands of another; and furthermore, if the ring (say one of the ordinary weight or a light one) is irregular in shape, one must be very careful to get several measurements of it, and then average them all to get the correct size, and but few will take the trouble to do this. What is wanted is something that, for a given ring, will register the same size, no matter who measures it. A round taper mandrel or gauge, the same as those now in use, I consider fulfils these conditions.

As nearly every manufacturing jeweller has a ring gauge of his own, the divisions or numbers of which are arbitrary, it has been a source of great annoyance both to the retailer and the manufacturer, and I am glad to see that there is great probability of "Allen's Standard Ring Gauge" being made the standard; not because it *is* Allen's, but because it is the best gauge I have ever seen, and has been endorsed by many of the leading houses in New York. It is some 10 or 12 inches long, divided into 13 sizes, and these again subdivided into $\frac{1}{2}$ and $\frac{1}{4}$ sizes, and on the small end a separate gauge for cutting off gold to the proper length for every size ring wanted. The gauge proper is made of metal, in the form of a hollow cylinder, into which is fitted a wooden mandrel, which allows of its being light and firm. The divisions and figures are all plainly stamped in the metal. I have laid aside all my old wooden gauges, as every jeweller will who obtains one of them. These are made by F. E. Allen, Keene, N. H.

I wish that we had a standard gauge for Geneva glasses. I have three different kinds of Geneva glasses, evidently sized on different so-called standards, as each kind differs in size from $\frac{1}{16}$ to $\frac{4}{16}$ in size from the other, so that apparently one may have a complete assortment of glasses and yet be unable to fit some particular watch. As these glasses are made and sized in Europe, it is doubtful if any standard gauge will be adopted then for some time to come, unless some one or more men over there like Mr. Grossmann, who are such noble lights in the Horological world, will agitate the matter to such an extent as to get the manufacturers interested in the convenience and welfare of the thousands of watchmakers and jewellers who are obliged to keep a stock on hand.

Speaking of Mr. Grossmann, I wish that he would give us a treatise or a series of articles on the chronometer, duplex and cylinder escapements. He has the happy faculty of being able to write so as to be understood by those who lay no claims to a scientific education, and that

means the great majority of watchmakers. His treatise on the Detached Lever Escapement is a valuable work, and should be in the hands of every watchmaker, and no one will ever regret the small outlay necessary to obtain it.

JAS. FRICKER.

Americus, Ga

Bench Keys.

ED. HOROLOGICAL JOURNAL:

I have lately noticed in the JOURNAL one or two communications in relation to Ring Gauges, and desire to inform your readers that I am making *both* forms of the gauge—the round and the flat—each corresponding with the other in graduation of sizes or numbers, so that dealers can have their choice. I regard the *round* gauge much the best, however, for if a ring is not perfectly round, or if not very heavy and stiff, so as not to spring any, it can not be accurately measured on the *flat* gauge. I wish also to have it known that I am now making the *round* ones stronger than formerly, and the wood is fitted in them so that they are solid their whole length. I also make them of *steel*, to use at the bench, in rounding up, etc.

Herewith I send you samples of Watch Keys that I am making, the pipes of which are tempered, and have perfectly square holes their whole depth. I know they are the best key ever offered to the trade. I can put dealers' names on the handles, when desired, for a trifle in advance of the regular price. The Bench Keys I sell for $2 per set, instead of $2.25, as advertised.

Keene, N. H. F. E. ALLEN.

Long and Short Screw-Drivers.

ED. HOROLOGICAL JOURNAL:

In your October number there appears a communication from Cleveland in which the writer ridicules the idea of a long screw-driver having more power than a shorter one. He says, "I should require more facts than I have seen or heard of, to prove that the assertion of there being more force in a long handle than a short one was true." Now I am not referring to long handles merely, but long screw-drivers; and I will mention a circumstance which I think goes a long way to prove that there is more power in a long screw-driver than in a shorter one.

A few days ago I was helping the gas-fitter to make some alterations on the gas fixtures of our store, and in the course of these alterations it was necessary to remove an old coupling from the end of a piece of iron pipe. I placed the coupling in my bench vice and fastened a large hand-vice on to the pipe, but all the force that I could apply would not start the screw. I then put the same hand-vice on the extreme end of the pipe and was able to screw it out of the coupling at once.

I do not know whether this is an old question or not; all I know is that it is new to me, and I would rather have the question answered than be laughed at. I felt some diffidence in writing to you about it at first, and before I did so made sure that I was correct in my opinion; and I still maintain that there is more power obtained by a long screw-driver than by a short one. E. D.

Hartford, Conn.

Answers to Correspondents.

G. A. M., *Philadelphia.*—We have communicated with the author of "Reminiscences of an Apprentice," regarding your query as to how the minister's housekeeper could wind up the clock when the case was locked, and the minister from home with the key in his pocket, as was described in the September number of the JOURNAL. He writes us as follows: "Different makers employed different methods for securing their cases, but they nearly all used locks on the door of the body of the case, leaving the glass door in front of the dial to be opened at pleasure. Some fastened a piece of stout wire, bent to a right angle, on to the frame that holds the glass, and when it was shut a bar fastened in the inside of the case was pushed into the corner of the bent wire, which prevented the glass from being opened, and at the same time secured the head of the case from being pulled off. In the better class of cases

a piece of iron with an oblong hole in it was used instead of the bent wire. Another method occasionally used for fastening these cases was, to have a bar in the inside simply for the purpose of fastening the head, while the frame that holds the glass was secured by means of a lock and key. There are, however, thousands of this class of clock cases in existence that have the head of the case fastened by a bar from the inside, and the door on its body secured by a lock, but have no fastening whatever on the glass door on the front of the dial to prevent it from being opened at pleasure. This was the manner in which the minister's clock case was fastened, and I have no doubt that many of your readers on this side of the Atlantic have seen old clock cases in various parts of the United States, and in the Dominion of Canada, secured in a similar manner."

J. S., *Leavenworth, Kansas.*—When the hour circle of a clock dial is divided into twenty-four parts, the ordinary numeral figures are used, beginning with 1 and running up to 23, and the 24th is usually marked 0. The reason for this is, that clocks with such dials are generally used for measuring sidereal time, and as a sidereal day contains only 23 hours and some odd minutes and seconds of ordinary time, it is not necessary to have the 24th hour. We will describe the manner of measuring tenths and hundredths of a second in an article which will appear in an early number of the Journal.

———o———

New Watchmaker's Lathe.—Mr. Ballou, of the firm of Ballou, Whitcomb & Co., 18 Harvard Place, Boston, favored us with an examination of their New Lathe, which is superior to anything of the kind ever before offered to the trade. An extended description of it will be given in the December Number of the Journal.

AMERICAN HOROLOGICAL JOURNAL,

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G. B. MILLER.

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All communications should be addressed,

G. B. MILLER, *P. O. Box 6715, New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For December, 1872.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Subtracted from / added to Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Sunday	1	70.35	10 35.29	0.961	16 42 35.77
Monday	2	70.43	10 11.91	0.986	16 46 32.33
Tuesday	3	70 51	9 47.91	1.010	16 50 28.89
Wednesday	4	70.58	9 23.35	1 035	16 54 25.44
Thursday	5	70.64	8 58 25	1 058	16 58 22.00
Friday	6	70 73	8 32.64	1.079	17 2 18.56
Saturday	7	70.81	8 6.53	1.098	17 6 15.12
Sunday	8	70.87	7 39 97	1 116	17 10 11.68
Monday	9	70 93	7 12.98	1.134	17 14 8.23
Tuesday	10	70.98	6 45 59	1.150	17 18 4.79
Wednesday	11	71.03	6 17.82	1.164	17 22 1.35
Thursday	12	71 08	5 49.72	1.178	17 25 57.91
Friday	13	71.12	5 21.29	1 190	17 29 54.47
Saturday	14	71 16	4 52.56	1.203	17 33 51.02
Sunday	15	71.19	4 23.57	1.213	17 37 47.58
Monday	16	71.23	3 54.35	1.222	17 41 44.14
Tuesday	17	71.25	3 24 92	1.230	17 45 40.70
Wednesday	18	71.27	2 55.32	1.237	17 49 37.26
Thursday	19	71.28	2 25.58	1.242	17 53 33.82
Friday	20	71.29	1 55.72	1.246	17 57 30.38
Saturday	21	71.30	1 25.77	1.250	18 1 26.94
Sunday	22	71.30	0 55.78	1.252	18 5 23.50
Monday	23	71.30	0 25.77	1.251	18 9 20.05
Tuesday	24	71.29	0 4.21	1.250	18 13 16.61
Wednesday	25	71.28	0 34.15	1.247	18 17 13 17
Thursday	26	71.26	1 3.99	1.242	18 21 9.73
Friday	27	71.25	1 33.71	1.236	18 25 6.29
Saturday	28	71.22	2 3 26	1.228	18 29 2.85
Sunday	29	71.19	2 32 62	1.218	18 32 59.40
Monday	30	71.15	3 1.73	1.208	18 36 55.96
Tuesday	31	71.11	3 30.56	1.196	18 40 52.52

Mean time of the Semidiameter passing may be found by subtracting 0s.19. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	6 23 36.2
○	Full Moon	14 9 44.1
☾	Last Quarter	22 14 11.9
●	New Moon	29 18 36.1

		D. H.
☾	Perigee	2 23.9
☾	Apogee	19 1.3
☾	Perigee	31 2.4

Latitude of Harvard Observatory .... 42° 22′ 48″.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	Apparent R. Ascension.	Apparent Declination.	Merid. Passage.
	D. H. M. S	° ′ ″	H. M.
Venus	1 19 3 57.60	−24 34 9 9	2 21.5
Jupiter	1 10 13 51.62	+11 56 35.8	17 28.6
Saturn	1 19 21 17.19	−22 7 55.0	2 38 3

AMERICAN

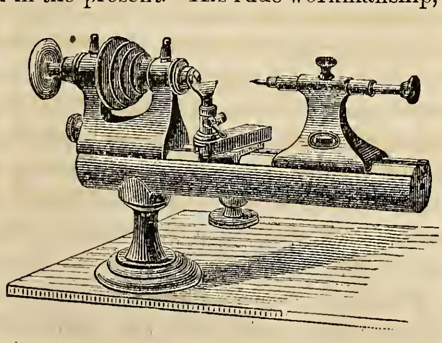
Horological Journal.

Vol. IV. NEW YORK, DECEMBER, 1872. No. 6.

CONTENTS.

Ballou, Whitcomb & Co.'s New Lathe.

With the wonderful increase in the sale and use of a better class of watches than were formerly required by the public, has sprung up an increased demand for more skilled labor, both in their construction and repair. The average watchmaker of the past would hardly be tolerated in the present. His rude workmanship, and

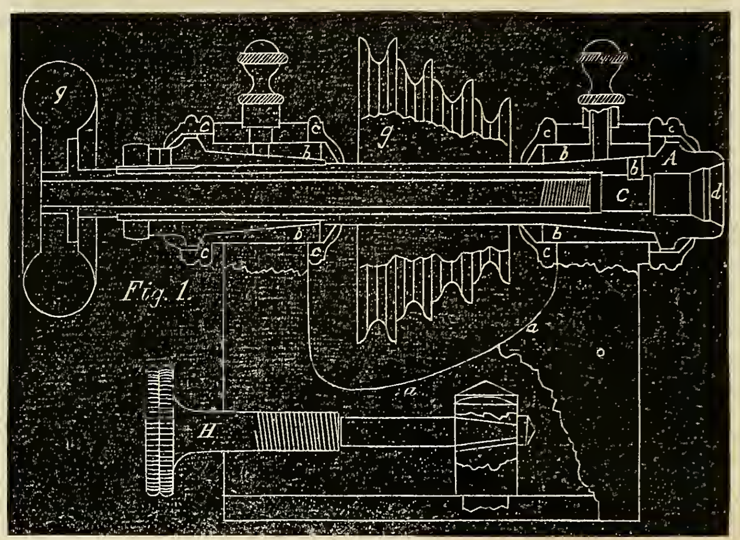


still more rude tools, applied to the fine watches of the present day, would be the death of their correct performance. The constant advance in mechanical skill has necessitated an equal advance in the construction of the tools and machines of the artisan. We remember the time when a "natural-born watchmaker," who could put in a verge with a pin vise and a few small files, was looked upon as a mechanical prodigy, and the performance of the machines thus repaired very well satisfied the demand of the times. By observations of the sun's altitude, shrewd guesses, and a doubtful reliance upon the watch, an average was arrived at as to the probable time of day quite accurate enough for those slow-moving times. Now all is changed; exact requirement of time compels carefully constructed timepieces, and these will not admit of careless construction or repair. Pivots and their holes must be round, wheels and balances must not be out of truth in their circumference, nor out of flat in staking on their pinions by so much as a hair's breadth, nor will the most trifling error in depthing be allowed; indeed, the exactness required is far in excess of the ability of the eye to detect and the hand to execute. An eccentricity in a small pinion, which no eye can see, may be so large a *proportion* of its exceedingly minute diameter as to vitiate its correct performance.

How then is this exact nicety to be attained? Evidently not by the hand and eye, but by *machinery*. "But," says an objector, "the machine must be made by hand, and how can the effect be more perfect than the cause? How can the work which the machine turns out be more exact than the machine itself?" Very true, it cannot; but within certain limits the hand and eye are adequate to detect errors within those limits. It is quite easy to see when a disk of ten inches in diameter, revolving in a lathe, is one inch out of centre, which will be an error of one-tenth of its diameter; neither is it difficult to see an error of one-tenth of an inch, which would be only the one-hundredth of its diameter; but no human eye could detect a want of truth in a staff pivot of one-tenth of its diameter, much less the one-hundredth. So, also, it is easy to place the points of compasses upon the inch marks of a scale; but what eye could place them accurately on so minute divisions as the one-hundredth of an inch; yet the one-hundredth of an inch can be accurately measured by the eye by

the intervention of a machine. To illustrate: take the proportional dividers or compass whose point of revolution is one inch from one end, and nine inches from the other; if the long legs are opened one-tenth of an inch, as they may be by the eye with considerable accuracy, the short legs will be opened one-tenth of that, which will give one-hundredth, which will be absolutely accurate to within one-tenth of the error of observation upon the long legs.

So with a lathe mandrel of an inch in diameter; if it has an eccentricity of one-tenth of an inch, the eye could at once detect it, and all the products of that lathe would have the same one-tenth eccentricity; but were the mandrel only one-tenth of an inch in diameter, the error would then be too small for the eye to detect. It is by this process that errors too minute for visual detection are eliminated; and it is made possible to construct tools of the requisite perfec-



tion—tools and machines sufficiently exact to be relied upon for producing the most delicate modern horological instruments.

For this purpose no simple machine is more in use than some form of lathe, and no machine has had more need of improvement. For the last hundred years everything in the way of accurate lathe work was done on the "dead centre" lathe. The advent of machine-made watches has given an impulse to improvements in live spindle lathes that bids fair to bring them to a great degree of perfection. There was, however, a pioneer in advance of the watch factories in bringing into notice the capabilities of the live spindle lathe. The wonder and admiration which the results Mr. Bottom wrought out with his lathe are yet in the memory of many an old watchmaker. He was the first, if the writer's memory is correct, who introduced to the general trade the live spindle lathe. This he did by personal effort, going about from place to place, producing and exhibiting specimens of skilful manipulation upon it which would even now be highly creditable to more pretentious instruments. To these efforts of Mr. Bottom are due the general introduction of the practice and practicability of chucking with cement. Later than this, the necessities of the watch factories compelled further advances in the same direction, the result of which has been the very general adoption of the split chuck in various forms, and a multiplicity of self-centring chucks, which are features of the modern lathe. As has been shown, the perfection of workmanship done upon the lathe depends upon the condition of the lathe itself, which, among the earlier ones introduced into market, was not favorable to perfection. Mr. Bottom's was better than very many which succeeded it, because he seems better to have comprehended the true principle of their action, and to have given much care to its construction which many of his successors did not; his imitators seeming to think that anything which revolved, and upon which chucking could be done with cement, was all that was required—

apparently placing more reliance on it than on the lathe. The same may be said of many of the self-centring lathes now in market; more dependence seeming to be placed upon the fact that split chucks are used, than upon the perfection of the chucks and the arbor that carries them. This faulty execution of an excellent principle has been the father of immeasurable prejudice against the use of live spindles for fine work; objectors who did not look below the surface jumped at once to the conclusion that that style of lathe was useless, and consequently condemned them as a class—condemned the principle because the badly constructed machines did not properly illustrate it.

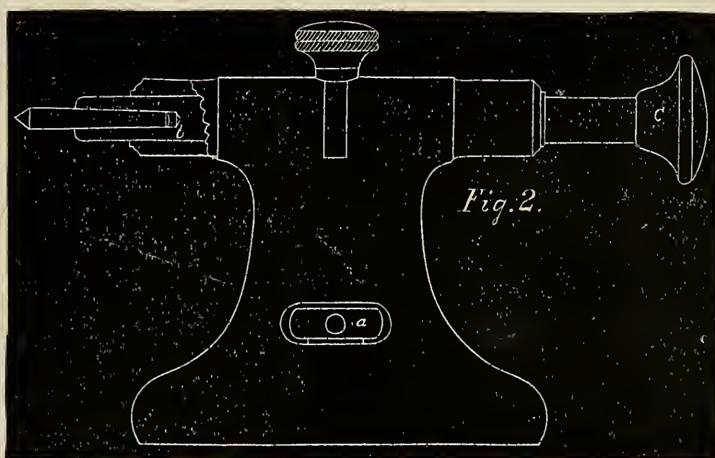


Fig. 2.

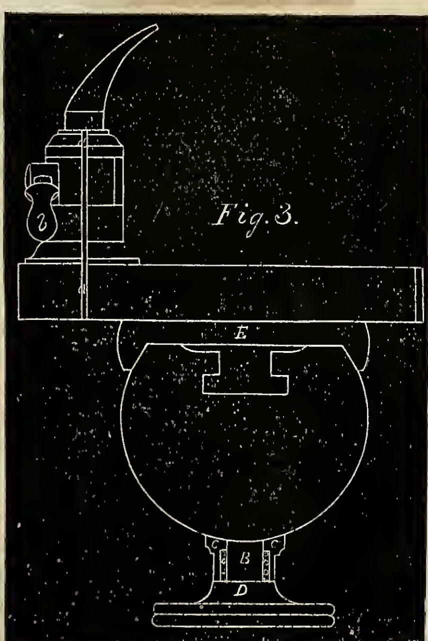
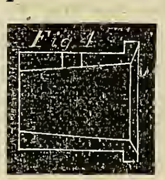


Fig. 3.

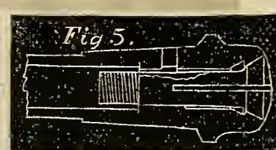
Our predecessors were not wholly blamable for the character of the machines they produced, for, as has been shown, the more perfect the machine the more perfect the work it produces. The modern demand for fine machinery in all departments of the mechanic arts has brought about the construction of some most exquisite work; consequently the facilities for producing fine lathes are constantly increasing. The growing demand for such instruments is also stimulating their production. Each successive competitor for public favor must possess more good points than its predecessor. One of the latest has just been brought out by Messrs. Ballou, Whitcomb & Co., of Boston, which, in its general features, resembles the American lathe, so long and favorably known. It has, however, some peculiarities of construction which cannot fail to commend it to the favorable consideration of the trade; not so much for any novelty which it possesses, as for the evident care which has been bestowed upon its essential parts. The makers possess ample facilities for this class of work, and seem not to have stinted themselves in the use of them in producing this lathe. We give place to a full description, because it is the duty of the Journal to give whatever of encouragement it may to every effort to promote advancement in our favorite art, not only in its science and practice, but in the all-important accessories of tools and machines; and knowing that good work requires good tools as well as skill, every advance in

their construction will be chronicled with pride and pleasure.

As will be seen by the perspective view, this lathe resembles the American, with the exception that the tail stock is solid. The cone of pulleys and hand-wheel for drawing in the chucks are of hard, black rubber, which contrasts beautifully with the nickel plating of the whole lathe. The counter-shaft is also an ornament to any work-bench. Where so much of the value of a lathe depends upon its truth, it is always of the utmost importance that the spindle (or arbor) and its bearings should not only be true, but so made that this truth will be maintained, if possible, during the existence of the machine. This can only be done by having the parts so fitted to each other, and of material so permanent, as to suffer the least possible amount of abrasion. In this lathe this point seems to have had proper attention. The spindle A, Fig. 1, and steel bush *b*, Fig. 4, are hardened so that it is impossible to make any impression upon them with a file. They are then ground with an emery lap to nearly a fit, and finished with a lap charged with diamond dust. After this is done they are run in their own bearings, and the inner chuck bearing *e*, Fig. 1, and mouth of the spindle *d*, Fig. 1, are ground to a standard by a diamond lap, making about 10,000 revolutions per minute—the lap and spindle revolving in opposite directions. The taper holes in the tail stock spindle, which is also hardened, are done by the same process. This method of finish will produce a journal and bearing that, with proper care, will be good an ordinary life-time.



Another peculiar feature is in having the female cone of the mandrel very short, its interior being cut away so as to bring the pressure upon the chucks at the very outer end, as near as possible to the article to be held, as shown at *d*, Fig. 1. This gives great firmness to the grasp of the chuck, and tends to prevent any untruth in the grasp. The chuck pin, *f*, Fig. 1, prevents the chuck from revolving when being drawn in, and it also precludes the possible twisting of the split chucks by overturning the draw-in spindle. The chucks in this lathe (both split and solid) are very short, and have a bearing at the rear or inner end, *e*, Fig. 1, which insures their being in line with the centre of the spindle. In favor of the short chucks this advantage is claimed—that the long chuck is easily sprung out of truth, and especially is this the case if a piece is held by the extreme front end; the chuck springing between the mouth of the spindle (or front bearing of the chuck) and its inner bearing; that the short chuck gives the best satisfaction, holds its shape better while being split, and also when being tempered, and the inner bearing comes more nearly in the centre of the front bearing of the mandrel—that being the firmest part of the spindle. The cone of pulleys is the reverse of ordinary forms, which is an improvement, as it allows the principal support which the headstock gives the spindle to have additional strength at its front end. The brass caps, *c*, Fig. 1, the makers claim protect



the journals from dust, and we think them equally useful in protecting the workman from grease; for in use the oil is constantly working out of the journals, besmearing the lathe and the hands; these caps prevent that, besides giving to the lathe a finished appearance. H, Fig. 1, is the wedge-shaped binding screw which secures the head stock in position.

Figure 2 is a sectional view of the tail stock. It has but one standard, with a long bearing surface for the mandrel, which gives it great firmness, and is secured upon the lathe bed by the binding nut, *a*. The tapers in the mandrel, *b*, are all hardened and ground, and the taper hole in which they fit ground to gauge.

The T rest is decidedly commendable for its convenience, and the smoothness and ease with which it is shiftable. The column which carries it is split at *a*, Fig. 3, and drawn together upon it by the arm screw *b*. The pleasant, easy motion of the rest carried upon its flat seat E, and also of E upon the lathe bed, is accomplished by being both held gently down by a spiral spring, B, enclosed between the washer, *c*, and the nut, D. The plate E also prevents

the dirt and turnings from lodging under the sole of the rest.

Figure 5 gives a very clear view of the chuck in place, showing its points of contact with the spindle, and also the guide pin.

Figure 6 gives a view of the counter-shaft and pillars that support it. The pulleys and cone are hard rubber, and the pillars nickel-plated.

The makers furnish with the lathe six split chucks, two step chucks, one taper, one screw, and one saw chuck. The largest split chuck in all the different sizes of lathes will take the wire which the tapers are made from, allowing it to pass through the chuck. The chucks are all made to a standard gauge, and are interchangeable, which allows any one to order extra

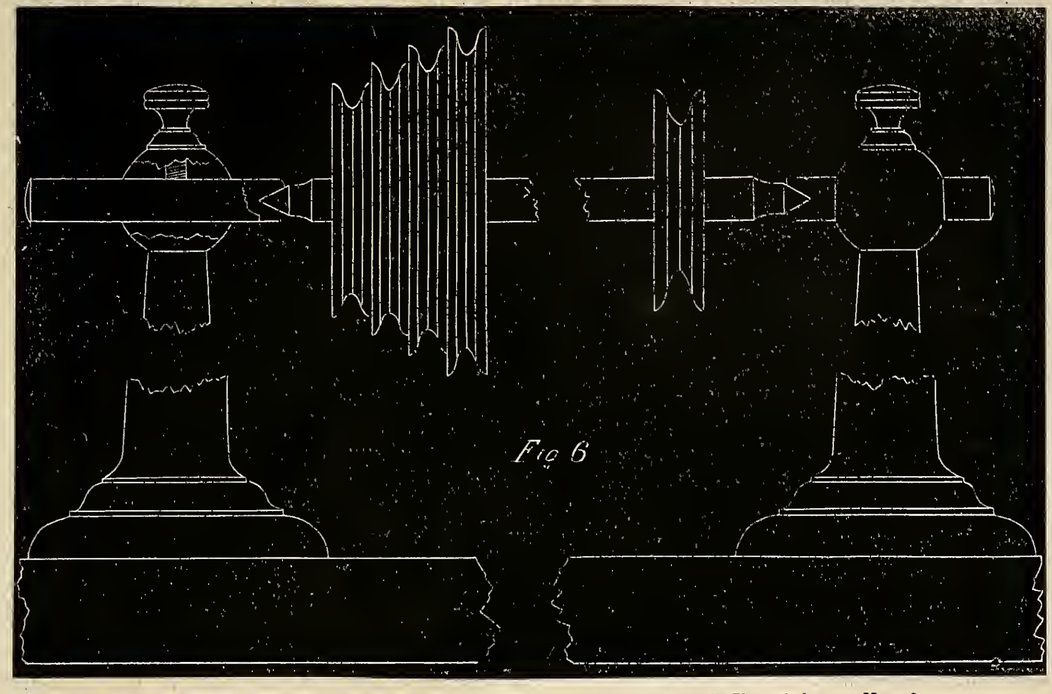


Fig 6

chucks at any time that will fit, and at the same time be true. The No. 1 lathe bed is 8 inches, and swings 3 inches. No. 2 lathe bed is 12 inches, and swings 4¾ inches.

Messrs. Ballou and Whitcomb have each spent about eight years in the construction of lathes in the principal American Watch Factories, and fully comprehend the requirements of this most useful tool.

Taking it all in all, it is by all odds the best lathe yet offered to the trade, and shows a progress which in all probability will not stop at this point. There is no good reason to doubt but that the same advancement will be made in watchmakers' lathes as has been made in those in use in first-class machine shops. There certainly is no end to the uses to which they may be applied; even now work can be done on them that a few years ago would have been pronounced impossible. Consequently we speak of this as a praiseworthy step onward and upward.

Watch Repairing.—No. 6.

BY JAMES FRICKER, AMERICUS, GA.

We have now arrived at the centre wheel, and will have a few remarks to make on that and its pinion, pivot holes, etc. No doubt there are some, if not many, who are in their "teens," so far as watch work is concerned, but may be old in years, that will wonder what any one can find to talk or write about concerning the centre wheel and pinion, as they evidently never do anything to them; and as for the centre holes, why, a few taps with the hammer on a round punch will close up the holes, and if it does throw it out of upright, and make it rub against the lower side of the barrel or fuzee, it can be filed off, or, if it rubs the lower plate, *that* can be remedied by turning out the plate on the Universal Lathe; or, in the absence of that indispensable tool, it can be scraped with a graver, or the lower side of the wheel filed sufficient to allow it to "go," and as for the lower

hole being made very *thin* by this punching process, that is nothing.

If such people did not exist, certainly so many watches would not tell the same tale, and watchmakers would not be accused of "stealing out the jewels" quite so often; for if a man's watch performs well after being repaired, its owner very naturally concludes that his watchmaker is one of the honest, good workmen.

The centre pivots, especially the lower ones, are usually the first that begin to show any signs of wear. The pressure on the lower pivot is great, and its hole is usually made too thin; consequently the pressure is exerted on a very small surface, the oil is all forced out, and small particles of dust get forced into the brass, if a plain watch, which acts as a "grinder" on the pivot. The pivot soon gets dry and rusty, small particles of steel become imbedded in the hole also, and last, but not least, the rust also, which is the oxide of iron, the same thing as crocus or "polishing stuff," only made somewhat differently. What watchmaker would think of leaving a particle of this on a pivot when he put the watch together? And yet some will apply a little oil to a rusty pivot and say that there is nothing the matter with the watch. New oil will not cure such a complaint, but the following process will.

Shellac the pinion up in the lathe, true it up by the old pivot where it is not worn, turn out every sign of a groove, and get the pivot straight and true; then grind and polish, same as for the fuzee pivots; then broach out the centre hole, file up a piece of hard brass wire to fit it, then rivet it in; the holes should be slightly chamfered on both sides, and in riveting in the bush do not hammer it so hard as to stretch the plate; pin or screw the plates together, put up in the universal lathe and centre from the upper hole. By this means you will get the wheel in upright, which is a very important thing. Centre and drill a hole a very little smaller than is required, then true out the hole with a cutter, for the drill will not make a round hole, and may get it a little out of centre; take the plates down after having finished the lower end of the hole, broach it to fit, and polish with the round broach. The upper pivot and its hole can be treated in the same way, if necessary.

It sometimes happens, by turning out the worn portion of the lower pivot, that all the shoulder for the cannon pinion is turned off, and the cannon pinion will go down to the shoulder. It would certainly not do to leave it in this condition, for the cannon pinion would then bind against the plate; but you can drill a hole in a piece of steel wire and cut off a piece just a little longer than the old pivot, and fit it on tight, being careful to have it come tight up against the shoulder, then temper it, and, if necessary, use a very small piece of soft solder to hold it fast. If acid is used to make the solder hold, wash the pinion in clean water, then in alcohol to get rid of every trace of the acid, otherwise the watch may stop in a few days, and which, on inspection, will reveal a rusty pivot. Having got the collar fastened on, turn up a pivot to the proper size and polish it as directed for the fuzee pivots. If the job is neatly done, no one would ever discover it, and will save putting in a new pinion.

If the upper pivot is broken, a new one must be put in. Hold the pinion in a pair of plyers and direct a sharp flame from the alcohol lamp, with the blow-pipe, against the extreme end of the staff of the pinion and bring it down to a light blue, being careful not to discolor the leaves of the pinion. If you do get them to a blue, however, you may remove the color by immersing the pinion in diluted sulphuric acid, washing immediately in clean water, then in alcohol. Cement the pinion up in the lathe and true it up by the outside of the staff part of the pinion, then with a hard drill, a trifle larger than the pivot to be made, drill a hole in the end, revolve the lathe very slow, working the drill back and forth all the time, which will prevent its becoming "choked," and have a less tendency to "polish" the bottom of the hole. In the latter case, use a little sulphuric acid in the hole to roughen it so that the drill will "bite" again. Drill the hole once and a half as deep as the pivot is to be in length, then get a paper of the best needles, select one and draw it down to a deep blue, file it to fit the hole, and cut off enough to make the pivot, allowing for depth of hole; drive it in tight and then turn down to the proper size, and grind and polish as directed for fuzee pivots.

In case one of the leaves of the pinion is broken, or if the pinion is badly worn, or too large

or too small, a new one must be put in. As we will devote one article to pinions, we will defer giving directions for putting in a new one until we come to that subject, and will then give directions for putting in the centre, third, fourth, and scape pinions. If the cannon pinion is too loose, never resort to the very common but pernicious practice of putting in a hair or piece of tissue paper, as this method will throw the cannon pinion to one side, and have a tendency to make the hands lock. The best plan is to place that portion of the centre pinion staff that goes in the cannon pinion between two files, rolling it carefully back and forth a few times, using considerable pressure, which will raise a very even, file-like surface on the staff, increasing its diameter by means of the roughness sufficient to make the cannon pinion hold tight. If this process fails to tighten it sufficiently, it will be best to put on a new cannon pinion.

The centre wheel will frequently be found to have several teeth soldered in, or the teeth may be worn so as to cause the watch to stop, in which case, a new wheel must be put in. Select one of the proper size, and number of teeth and stone it up flat and of the proper thickness. It may be necessary to file it some on one or both sides before stoning, after which polish it on boxwood with Vienna lime and alcohol, or gild it as may be required, using a scratch brush to remove the burr from the teeth. Remove the old wheel and put the pinion up in the lathe, and turn off the points of the leaves that held the old wheel on; take down the pinion and put up the wheel, using a hollow chuck; true up the wheel by the outside, as it frequently happens that the hole is not in the centre. With a cutter, turn out the hole to fit the pinion, take it down, and after having cleaned it and the pinion of shellac by boiling in alcohol, rivet it on. For this purpose, every watchmaker should have a good staking tool, of which there are several in the market; but, not having used them all, cannot speak of their respective merits, and in these articles shall speak of no tool only from actual experience. Some years ago we made a staking tool, which any one can make, as follows.

Take an old "upright tool" and fit a dozen small hollow "stakes" to it, each one with a different sized hole, so as to accommodate any sized pinion; make the upper end perfectly flat and true, with a shoulder on the other end, each one of which should just fit into the hole in the plate of the tool, projecting above the plate about one-fourth of an inch; cut off the end of one of the centres, or rather both ends, and drill a hole in one end of it, and bore it out slightly taper for about half an inch; then make a dozen or more punches to fit into it, making a round end and flat end to one of each size, drilling holes in the ends to suit any size pinion, then temper and polish all the punches and stakes, leaving them a light straw color; also make two for staffs; drill a very small hole in the one for fine pivots, and then chamfer the corners of the hole, and in the other drill a larger hole and chamfer in the same way. If it is necessary to drive out or in, a pallet staff, for instance, put a stake in the hole in the plate that will freely admit the staff, lay the pallets on it with the large end of the staff down, select a punch that will admit the pivot, but not the staff (two sizes will do for all), put it in the old centre, which now answers for the handle to the punch, and then put it in the hole of the tool and bring it down on the pallets so that the pivot will enter, and a slight blow on the end will drive out the staff, and will never break or bend a pivot, neither will it in putting the staff into the pallets. This we have found to be a valuable tool.

For riveting in the centre wheel, select a stake that will just freely admit the upper staff of the pinion, and place it in the plate; select a round punch that will just pass over the shoulder of the lower pivot and put it in the piston; place the pinion in the stake, lay the wheel on it and proceed to rivet it down, turning your punch at every stroke of the hammer. When firmly riveted on, take out the round punch and put in a flat one, giving it a few taps. If the punches are well polished, the pinion will not be disfigured but very little, if any, and a little polishing will bring it up right, if a fine watch, and if an ordinary one, no polishing will be required. With this tool a nice job can be done, and done quickly.

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We take pleasure in calling the attention of the trade to Kelley's Soldering Kit as being one of the most convenient and useful adjuncts to the watch bench ever offered to them.

Rounding up Cones.

The following is a translation from the French of a pamphlet describing a new instrument for giving to the teeth of wheels the proper epicycloidal form. For the repairer it would appear to be just what is needed to enable him to correct bad gearing, resulting from improperly shaped teeth, as well as for replacing a new wheel, and which is a tool simple, inexpensive, rapid, and theoretically correct as to the work done by it. We are unable to say who is the inventor of it, as his name is not made known, nor the place where they are made; but certainly such an instrument is desired by every watchmaker. We give the details in full of Les Cones Arrondisseurs, or *Rounding Up Cones.*

"It is sufficient to have been occupied somewhat with mechanical horology, to appreciate the importance or effects of a good or bad gearing. The quality of action desirable in a wheel and pinion is expressed in the following three points: Uniform transmission, proportionally equal velocity, and an action free from friction. This triple desideratum in a gearing can be obtained only on condition of combining the mathematical relations of the diameters with a correct form of the teeth. The foregoing embraces theoretically all the points in question, and it may be mentioned that practical solutions have been found for nearly all these problems, with more or less degree of accuracy for the last mentioned—" the good form of the teeth." In this short treatise we shall occupy ourselves only with this last question, which of itself deserves the attention of the most scientific minds. It is needless to here recall the theory of the epicycloid, according to which the configuration of the teeth of wheels and pinions ought to be. The reader must be already familiar with it; besides, there exist special treatises to which he may refer. What is certain is, that in fine gearing, such as is in watches and other accurate mechanisms, the curves or rounding of the teeth ought to be made with extreme geometrical precision, without which their functions will be worse in proportion as the motive power is weaker.

"Up to this day we have sought in vain for the mechanical means of giving to the teeth of wheels their proper shape, as prescribed by mathematics, owing to the fact that we have to deal with infinitely small parts, inaccessible by compass or any linear measurement; or, in other words, no practical tool has been made, easily managed, rapid and economical, as the one which we shall presently describe. Still, it is but due to state, that the road toward the solution of the problem has been cut by men as eminent in science as they were skilful, and that several apparatuses are existing, which we shall here review. But first, let us state the problem to be solved. Having given a pinion driven by a wheel, to give to the teeth of the latter a shape such that, at every point of contact with the leaves of the pinion, the form of the rounding of the teeth be exactly that which the leaves of the pinion would give them had they the faculty of abrading them by the simple contact of rotation. In other words, having given a wheel, the teeth of which are not rounded up, to apply to it a tool identical in shape with its pinion, and able to round up its teeth according to the form required by the pinion.

"There exist four different kinds of tools to accomplish this result:

"1*st.* The ordinary rounding-up fraise.

"2*d.* Saunier's rounding-up tools of precision.

"3*d.* Ingold's fraise.

"4*th.* The rounding up cônes C. J. B. Z.

"1*st.* The ordinary fraise, particularly the one called an endless screw, is a very ingenious invention, and of very expeditive application, but nothing which guarantees exactitude or good work. In fact, how are these tools so generally employed made that are to give to the teeth of wheels their proper shape? At the hazard of the hand, according to the notions of the workman, of a shape to satisfy the eye, but in no degree on geometrical principles. By their means production is rapid, but the market is also stocked with an abundance of defective wheels.

"2*d.* Saunier's rounding up tool of precision is an admirable instrument, realizing, so to say, the dream of a geometrician; it takes hold of the tooth, guides it to the fraise, and carries it before the latter according to the theoretical curve of the rounding necessary, which is the dividing machine identified with the rounding up tool. This invention is too little known, and if manufacturers would

make more use of it, there would be nothing but perfect teeth in wheels. Notwithstanding its incontestable merit, this machine does not enter into the usual work.

"3*d*. Ingold's fraise is an idea exactly in conformity with the demands of the problem enunciated above. This tool is nothing else than a pinion, the spaces and sides of the leaves of which are finely cut like a file. Placed into gear with a wheel to be cut, it gives to the teeth their form by filing them according to the theoretical curve. This would appear to solve the problem. After this invention we might have thought that there was no need of seeking for another ; and the question arises, why this tool is not in the hands of every workman. Probably the greatest obstacle to its becoming generally used is the difficulty to get a complete assortment. For every dimension of teeth a separate fraise is necessary, and as the number of the dimensions of teeth is infinite, it follows that this tool cannot be completed ;—at least, it would become enormously expensive.

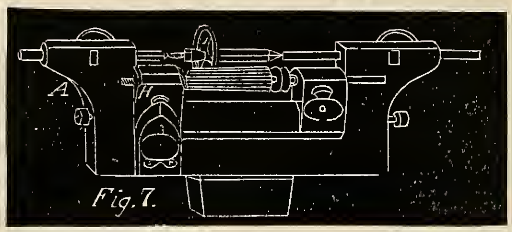
"4*th*. The rounding up cone C. J. B. Z. is a tool of the same kind as the preceding one. This is the new instrument which we would present to the reader.

"As its name indicates, it consists of a small cone of steel toothed similar to a pinion, and drilled through ; in order to be placed opposite a loose arbor. The taper of the cone is one-twentieth ($\frac{1}{20}$) of a millimetre for every millimetre of length ; or for a length of twenty millimetre there is one millimetre difference between the diameters of the large and small ends. This proportion, perfectly suitable for the thin wheels used in watches, is reduced to one-half in the cones destined for the larger work of clocks, so that the taper of the cone is only one-fortieth ($\frac{1}{40}$) for every millimetre in length. Eight cones form a complete assortment, comprising, without the least exception, all the sizes of teeth existing from the smallest to the largest watches. In other words, this assortment of eight pieces represents, without any interruption, all the imaginable dimensions of teeth from a pitch of one-tenth of a millimetre to that of two millimetres.

"For the larger work of clocks ten cones will form a complete assortment, realizing all the conditions enumerated, and comprising all the sizes of teeth from the pitch of one millimetre and a half to the pitch of four millimetres. But this is an exceptional number. An assortment of five cones plainly suffices for all usual work. Besides this double assortment, satisfying more than abundantly all the requirements of practical horology, cones of special size and teeth can be made as desired. But the exceptional merit of this new tool is, that under all imaginable hypotheses, the number of pieces comprising an assortment is exceedingly limited, and consequently very economical.

"If we consider that, in order to possess a rounding-up tool approximately complete, it was necessary to spend at least one hundred and fifty or two hundred francs, and for an assortment of Ingold fraises from three to four hundred francs, and that by using the rounding-up cones, by which the same result can be obtained, a sum of about fifty francs is sufficient, it cannot be denied that progress has been made, and that the introduction of this tool is a great advantage.

"To better understand the tool, and the manner in which it is used, the following description will suffice. The accompanying cut represents a depthing tool made especially for the



purpose, but any other depthing tool may be used with equal satisfaction ; besides this, an appendage is also made, called a cone carrier, which may be used in the place of the T rest of any ordinary Swiss bow lathe, without any previous preparation. The tool represented in the cut may thus be dispensed with, although it costs but one half of an ordinary depthing tool ; only, as it is especially made for the purpose, the work in question may perhaps be done with greater accuracy. The following is the manner in which it is used.

"The cone being placed upon a loose arbor running between the centres of the depthing tool, or cone carrier, is set in gear with the wheel to be rounded up, just like a pinion with its wheel ; these are simply set in motion with a string bow, and it is immaterial whether the

bow is applied to the wheel or to the cone; thus the work proceeds. Naturally the operation is begun with a shallow depth, and as the tool is closed by degrees, making the gearing deeper, little pieces are seen to fly off, cut just as neatly as if a cutter were employed. After a few strokes with the bow the work is completed, and the teeth will appear brilliant, regular, and polished in the highest degree.

"An essential point is the choice of the proper cone, but nothing is more simple. The operation is commenced by putting the cone and the wheel together at a point where their depth is good; that is to say, like that of a good pinion and a good wheel well set; in other words, a point in the gearing is chosen where, the teeth of the cone and those of the wheel being equal, there is no butting or fall, neither at the entrance of the teeth, nor at their exit. There is hardly a workman who will not instantly comprehend these details. This being done, the wheel is moved a little towards the small end of the cone, so that there will be a butting against the sharp angles of the teeth of the cone (which will become progressively smaller with respect to those of of the wheel), and the work begins. It is by this colliding of the sharp cutting angles of the cone with the unrounded portions of the teeth of the wheel that the former gives to the latter the desired shape.

"After the first few strokes, if it is desired to obtain a still more perfect result, *i. e.*, a more decided curve, it will be only necessary to bring the wheel still a little further towards the small end of the cone, setting them in motion anew, and closing the depth progressively. Care must be had to cease immediately upon the disappearance of the last vestiges of the flat at the points of the teeth of the wheel. If the operation were continued, the teeth would become disfigured, and instead of an epicycloidal curve there would be but a rough and uneven surface. This is evident, that in overstepping the proper limits a bad result would be obtained, like that of a wheel in gear with too small a pinion.

"For similar reasons, but diametrically opposite ones, if a cone were used at a place where its teeth would be larger than those of the wheel, instead of rounding them up it would disfigure them. It is scarcely to be feared that any workman will commit these extreme errors, yet it seemed necessary to point out these chances of trouble in the way of a precautionary admonition.

"When the work is brought to the point above mentioned, if it is desired to obtain the highest degree of perfection, the wheel is replaced, turning it end for end between the centres of the tool (lathe or depthing tool), and it is set in motion anew with the cone at the exact place where it was before. This short operation consists of two or three strokes of the bow; after this, the wheel is brought a little towards the larger end of the cone, about to the place where the operation was commenced, and a few drops of oil put to the teeth of it; then give about five or six light strokes with the bow, guiding the motion of the wheel with the end of the finger, and the whole work is done. The wheel is to be stoned off on both sides, washed and cleaned, and then with the glass it can be verified that no polish with rouge equals that on the rounded up teeth done by this process. This polish is the more perfect, as the acting surfaces are cut lengthwise in the teeth, which is an improvement on the ordinary rounding cutters, which leaves, of necessity, the lines cut crosswise.

"Recent improvements have added an important property to these cones, which permits of varying the form of the teeth according to the desire of the operator. The sides of the leaves of all the cones are very delicately cut longitudinally like a file, so that they abrade like exterior sharp angles, and thus act upon the teeth. This enables the operator to operate only with the sides of the leaves, as for instance, when it is desired to re-touch a wheel which has already been rounded up, and thus to make with certainty re-touches of infinite delicacy without running the chance of overdoing it, even should the operator be entirely a novice in the management of the tool. For this purpose the cone and the wheel must be put together precisely at the place where there is no butting or colliding, nor fall, and where their gearing is that of a good wheel and pinion properly set, as before explained; then, after having put a drop of oil to the points of contact, they are set in motion, and the work is being accomplished as the depth is closed by degrees.

"If it is desired to obtain a less oval shape of the teeth, such as is required for the pinions

of low numbers, it will suffice to bring the wheel successively toward the smaller end of the cone, being careful that it be not overdone, so that the outer sharp corners of the cones commence to cut. Thus is realized the power of proportioning the form of the teeth to the number of leaves in the pinions employed. The use of these cones in the most celebrated houses in France and abroad has given the very best results. In the house of Bréguet trains of telegraph apparatuses have been brought to working perfection unheard of. If necessary, it will operate on and round up wheels of a thickness of $\frac{1}{15}$th of a millimetre, and the pitch of which is from three to four millimetres. This is certainly the maximum of large work. In the same house an extreme sensibility has been obtained for anaroid barometers. The teeth of a wheel to be rounded up were those of one not exceeding three millimetres in diameter, and the pitch of which was $\frac{3}{10}$ths of a millimetre. This was incontestably the minimum of small and delicate work. It need hardly be said that all these operations must be performed with a care and delicacy usual in practical horology. Generally it is preferable to apply the bow to the pulley on the cone, with the precaution to make the bow as long as possible, and string with horse-hair or a fine silk cord. This silk cord, particularly when well waxed, is of great flexibility, and lasts five times as long as a gut. All the science of the rounding up cones is contained in the preceding lines. On the main, to studious artists, intelligent and skilful as watchmakers generally are, a short acquaintance with them will demonstrate all the advantages and facilities this new tool offers."

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The Cryptochylon Ice Pitcher.

In the third volume of the Journal, we gave a short description of the Cryptochylon, or solid walled Ice Pitcher, which had just then made its appearance in the market, commending it for its points of excellence, which seemed to us to give it a position in advance of any other pitcher which had yet been produced. The result of a year's experience has proved the correctness of our opinion, and justified our predictions of the position it would take in the market. It has already been adopted by many of the leading houses in the country, and when the new styles which are now being brought out are completed, so that all tastes may be suited by every variety of form and finish, it must occupy a still more prominent one.

A few words as to the method of constructing ice pitchers, and the material of which they are usually—we might almost say universally—made, will be of interest to our readers, many of whom are *sellers*, and most of whom are users of these useful articles. Previous to the introduction of the Cryptochylon, all ice pitchers have been constructed with a double wall—that is, with an inner vessel suspended from the upper edge of an outer one, leaving a space of from one-half to three-fourths of an inch to be occupied by a column of air which acted as a non-conducting medium. For a time this space was filled with various materials, such as plaster of Paris, charcoal, etc., but they were found to be objectionable in use, and were abandoned, leaving the space between the walls entirely vacant.

The metal used in their construction is commonly known to the trade as white metal; but it is far different in quality and character from the albata, or white metal, of which plated spoons and forks are made. This is nickel silver, as it is now termed, and is identical with German silver, although many have supposed there was a difference between them. It is a hard, ringing metal, composed of copper, nickel and spelter, more stiff and intractable than solid silver, harder to work, and more durable when completed. The white metal, of which ice pitchers and other articles of hollow ware are made, is of an entirely different composition, its principal ingredient being tin instead of copper, and the metal consequently soft and ductile. White metal is identical with britannia, a designation rather too old-fashioned to apply to *plated* ware nowadays. It is capable of taking on a brilliant finish when plated, but is entirely lacking in the stiffness required for a vessel subject to the treatment which an ice pitcher necessarily receives. The dents and bruises which disfigure the ice pitcher on so many sideboards testify to this, and the double wall makes it impossible to get at them for repairing without taking the pitcher to pieces and involving much ex-

pense. If nickel silver is used the cost is so greatly enhanced that the article is beyond the reach of any but the wealthy.

The "Cryptochylon" (or concealed wood) Ice Pitcher is made by turning a vessel of wood of the shape required and then covering the wood with metal by the process of spinning, thus producing what would be more accurately described as a pitcher of wood *clothed with metal.* The wood, which is one of the best non conductors of heat, makes of the pitcher an equally good ice preserver, and at the same time gives it much more solidity and resisting power than if made of the *hardest* metal which can be used for such purposes by the old method, and without adding to the weight or cost. So that while it can be manufactured at a price which places it within the reach of every family, it is as beautiful, and at the same time more durable than those constructed of nickel silver, which are within the reach of the wealthy only.

The use of ice, once considered a luxury, is fast becoming an absolute necessity for comfort in all civilized communities, and we gladly notice and commend the production of a cheap, beautiful, and *durable* vessel to economize, facilitate, and universalize its use. The advantages possessed by this new invention, over any other Ice Pitcher now in use, must be apparent to all who will give the subject consideration.

The manufacturers, Messrs. Adams, Hallock, & Co., have recently opened an office and salesroom in the Waltham Building, No. 1 Bond street, which will be a great convenience to their customers.

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Narrow Escape of a Renowned Horological Establishment.

It is with pleasure that we record the escape of the premises occupied by Messrs. William Bond & Son, from the ravages of the late conflagration in Boston. To the student of Horological subjects this house presents an interest which is not associated with any similar building on this continent. There some of the most difficult questions connected with our profession have from time to time been practically investigated in the most thorough and exhaustive manner, and what the laboratory is to the chemist, this establishment has been to many of the higher branches of our profession. In addition to the ordinary business of manufacturing and repairing marine chronometers and fine watches, the proprietors devoted much of their attention to the application of electricity for the purpose of recording astronomical observations with greater accuracy and precision than had previously been accomplished, and also to the improvement and manufacture of time-measuring instruments suitable for the requirements of modern astronomy and navigation.

About sixty years ago Mr. William Bond, the founder of the business, constructed the first chronometer made on the American continent. In those days materials were not to be had so conveniently as at the present day, and during the war of 1812–'14, the time this chronometer was made, no suitable materials could be imported from Europe, neither could they be procured here ; but this circumstance was not sufficient to stop Mr. Bond in his work, and from such materials as could be obtained in the blacksmiths' shops and brass foundries, he made every part of this chronometer, which, for a time, did good service in the United States Navy, and we believe is still in a good state of preservation.

Fully twenty years ago, when the application of electricity for the purpose of recording astronomical observations was proposed and was in the course of being put into practice, a mechanical difficulty presented itself, which for a time threatened the success of the whole undertaking. The cylinder or drum on which the paper is fastened could not be made to revolve with the necessary accuracy, and it was absolutely necessary that it should revolve with a steady continuous motion precisely once in a minute, or sixty times in an hour. The motion of this cylinder could be regulated by means of the vibrations of a pendulum so as to give the necessary number of turns with the greatest certainty ; but of course the cylinder would move in jumps, which rendered it entirely unsuitable for the purpose required. Some astronomers used a conical pendulum in order to produce a regular and continuous motion ; but, although very beautiful in theory, it was impossible in practice to make it work with the necessary precision. A fly was also unsuitable for the purpose, for, although it produced a smooth mo-

tion of the cylinder, it could not be made to turn once in a minute with the necessary precision, and the great benefits which promised to arise from the plan of recording astronomical observations by the aid of electricity at one time, from the above causes, stood in danger of not being fully realized.

About this period, the late Mr. R. F. Bond, a grandson of Mr. Wm. Bond, the chronometer maker, and son of Professor W. C. Bond, of Harvard University, undertook to construct a mechanism which would produce a continuous and regular motion of the cylinder, and in this effort he was eminently successful. By an ingenious arrangement which he called a "spring governor," working in combination with the vibrations of a half-seconds pendulum, he produced a uniformly regular, circular motion, and constructed the instrument known in astronomical circles as a chronograph. This instrument was immediately adopted by the U. S. Coast Survey, and one of them, exhibited by Messrs. Wm. Bond & Son at the World's Fair of 1851, received the Grand Council Medal, and these chronographs are now to be found in all the principal astronomical observatories in the United States and elsewhere. This method of obtaining a continuous uniform motion is also used in constructing the driving clocks of equatorial mounted telescopes. All of the large telescopes made by Messrs. Alvin Clark & Sons have clock-work regulated by Bond's Spring Governor.

After the chronograph had been completed a difficulty outside of the chronograph itself had to be overcome before the full benefits of the new method of registering astronomical observations, by the means of electricity, could be fully realized. The usual appliances for causing the standard clock to close and break the electrical circuit, and register the passing seconds of time on to the paper fastened on the revolving cylinder of the chronograph, by means of a pen worked by an electro magnet, did not always work with certainty. In ordinary telegraphy, if the operator's key fails to produce the desired signal, the operation can be repeated two or three times till the required signal is produced; but for the purposes of a chronograph any imperfect action of this part leaves a record of the failure on the revolving paper, instead of marking in a certain and legible manner the seconds of time as they are measured by the clock.

The difficulties to be obviated in perfecting a break circuit were twofold. One difficulty was mechanical, the other was chemical. The working of the various break circuits all disturbed the accuracy of the standard clock in a greater or less degree. The action of the electrical current on the metal from which the points of contact were made, decomposed the metal and a fine powder was deposited on the surface of the points of contact. The electric fluid can only be conveyed from one piece of metal to another when they touch each other, and when the points of contact are absolutely clean. As already stated, the natural action of the electricity has a tendency to make these points of contact dirty, and hence the apparently unsurmountable difficulty to be overcome in improving a break circuit. Mr. R. F. Bond, however, arranged the points of contact in his new break circuit in such a manner that any dust or dirt was prevented from collecting on the points of contact. When any dust or oxide was formed by the natural action of the electricity on the points of contact, it was immediately removed by the mechanical action of the break circuit itself, and in this manner the trouble occasioned by the products of the chemical decomposition of the points of contact were overcome.

The construction and improvement of a better class of clocks, with gravity escapements, suitable for the highest purposes of astromomy, is a specialty which has been carried on more extensively by this firm than by any other firm or private individual in the country. Their experience in this branch of the business has been very great. It would occupy an entire *volume* of this Journal to give an account of their labors in this direction, and the valuable deductions that can be made from many of these experiments.

We congratulate a firm whose members have accomplished so much in improving high class horological instruments, upon the narrow escape of their business premises, which, from cellar to roof, they have occupied so long for the accommodation of the various branches of their business, and where they have earned so much renown and experienced so much substantial prosperity. For a time it seemed im-

possible for that block of buildings, and all those on the south side of State street and immediate vicinity, to escape, but the fury of the devouring element was checked at a stage when buildings a few feet distant were in flames, and its progress was stopped. We hope in due time to see Wm. Bond, of the fourth generation, succeed to the same position so long occupied by his forefathers in the chronometer business.

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N. B. Sherwood.

DIED—In New York, Oct., 1872, of consumption, N. B. Sherwood, aged 49 years.

NAPOLEON BONAPARTE SHERWOOD, the subject of the present sketch, was personally known to many of our readers, and all are indebted to him for many valuable articles in the first vol. of the JOURNAL, to which he was a principal contributor, since which time the state of his health has incapacitated him for either physical or mental labor. In many respects he was a remarkable man. With a passionate love of study—especially in the higher branches of mathematics, astronomy and chemistry—a highly retentive memory, and perceptive powers that seemed almost intuitive, he was easily enabled to grasp any subject brought to his notice, and a peculiarly happy faculty of imparting information made him an interesting companion as well as valuable writer and instructor. After graduating with high honors from the Albany Academy, under the late Prof. Beck, he decided upon the practice of medicine as a profession, and entered upon that with the same zeal that characterized his other studies, and no young man ever gave more brilliant promise of becoming eminent in that profession; but a natural taste for mechanics gradually led him into more congenial pursuits, affording greater scope for his inventive faculties.

It was during the earliest part of his career as a horologist that he located in Jefferson, Ohio, in 1852, where our acquaintance with him commenced. Gravitating naturally to New York, he engaged in jewelling watches and chronometers for the trade, which was the means of bringing him to the notice of Mr. E. Howard, at that time connected with the Watch Factory at Waltham (then in its infancy), and resulted in his removal to that place, where he had abundant opportunity to bring his inventive genius into play in originating new tools and improving old ones.

Being placed in charge of the jewelling, he soon made a complete revolution in that department. Heretofore each watch was jewelled by itself, as was practised in England at that time, and is generally to-day. He invented what are known as "End-shake tools," "Counter-sinker or screw head tool" for jewel screws, the "Truing-up tools," and the "Opener." The first named are truly wonderful tools, being self-measuring, and so constructed that no matter to what depth the shoulder was cut in the upper plates, by putting the plate against one end of one of the tools, and the jewel with its setting in a spring chuck, the tool would cut a shoulder on the setting that would bring the face of each and every jewel exactly flush with the under side of the plate when the setting was put in. The jewels were then reversed and put into another chuck, and the top of the setting cut down by this magic tool until it would come exactly flush with the top of the plate, or rather leave just enough projecting above to allow for polishing. After the jewel settings were "stripped" and polished, they were put into the plates where they belonged, never to be removed again. As the plate was already gilded, next the holes for the screws were tapped out and the holes bored for each screw-head on the screw-head tool, that would leave the head of the screw exactly flush with the top of the plate and *not* raise any burr. The end-shake tool was certainly the perfection of self-measuring tools. By it the shoulder was cut on the setting of the lower holes (the holes in the plate being first bored out with a shoulder), so as to give each pinion and staff the exact amount of end-shake required. He could, with his end-shake tool, truing-up tool, face plates and countersinking tool, do nicer work than was ever done before on a watch already gilded, and more of it than five men could in the ordinary way. He found it was impossible to open a jewel hole by hand so that the hole would be perfectly round. It is a fact not generally known, that all the jewels made and opened by hand have holes in them that are not round, which can easily be proven by inserting a round broach (which is never perfectly round), and carefully turning it around, as some

place will be found where the broach will not turn. He also invented a tool that would open a round hole, one in which a round broach would not stick.

Such are a few of the wonderful inventions of his fertile brain. He could go into the machine shop and do more work on a planer, or a lathe, or at the vice, than the best of the machinists. In fact he usually not only invented his tools, but he made drawings of them that showed him to be an expert draughtsman, and then went into the machine shop and made them himself. Mr. Howard, the superintendent, consulted him upon every contemplated improvement in any department of the factory, and after the old factory was sold out, and Mr. Howard started his new factory in Roxbury, he found the ever fertile brain of Mr. Sherwood to be of incalculable advantage to him. New machinery of all kinds had to be constructed, and every improvement made on the old that could be devised. There being no "jewelling department" until new tools could be made, and no jewelling could be done until the other parts of the watch were ready for the jewels, he was so situated as to be of the greatest assistance in devising new tools and making improvements; besides which he was such an efficient hand in the machine shop that he was truly invaluable, and his knowledge of chemistry was of value in the gilding department, which was closed to all outsiders except him.

It would be impossible to enumerate all the improvements that were made through his advice in the factory. Mr. Howard acknowledged the value of his services by paying him nearly double the wages he paid the best of his other employees. He never patented any of his tools, for, like all great mechanical geniuses, he invented a tool, or method of doing anything, for the thing itself, with no thought of deriving any pecuniary advantage therefrom. Had he patented all his inventions he could have realized a handsome sum, as they are used in all of the watch factories in this country.

Alas! his train has run down; the vibrations of his heart have stopped; his hands have ceased to move; his face, blanched as a silver dial, only shows the time that has been; his case, which once contained all the moving mechanism of a man, now lies tarnished and corroded; we search in vain for the means to again put all in motion, for man, as yet, knows no way to replace the broken mainspring of life. Honor to all that was good in him—and peace to his broken parts!

Essays for the Burdett Coutts Prize.

We have the pleasure of laying before our readers two of the Essays offered in competition for the Burdett Coutts Prize, for which we are indebted to the *British Horological Journal*, and hope soon to be able to offer the two which took the premium, as well as the other one which was selected as worthy of especial commendation, offered by Mr. Ernest Sandoz, of this country. We have omitted, for want of space, the historical part of Mr. Ulrich's Essay, giving only that part relating to the Isochronism of the balance spring. The Prize was awarded equally between Mr. Henry Phillips Palmer and Mr. Morritz Immisch.

ON THE APPLICATION OF THE BALANCE SPRING AND ITS ADJUSTMENTS.

It is a very general practice, for what is termed an eleven-turn spring, to use only ten and three quarters, but I find it the safest way to leave it a little longer, so as to have some through the stud to spare in case of necessity, and to coil the ends at the stud and collet nearly midway between the diameter of the spring and its centre; and if requisite, as is frequently the case, a smaller collet must be made, and the stud made to approach nearer to the centre of the balance.

The spring will then have less dominion over the balance by not being put in tension so quickly; but if it gains in the short vibrations, it shows that the collet is too large, and that it has too much dominion over the balance, which is to be remedied by uncoiling the upper end and bringing the stud farther from the centre, or by a smaller collet.

If the collet is too small it will lose in the short vibrations. The quickest way to alter that is to make a larger one.

TO TRY THE ISOCHRONAL PROPERTIES OF THE BALANCE SPRING.

Place four pins about a quarter of an inch long, equidistant from each other, and allow the spring to be retained in tension a quarter

of a turn by one of the pins resting against a temporary detent placed on the cock (as nearly as possible) at right angles to the quiescent point.

Then place a weight upon the first pin that the spring will just sustain, after which turn the balance round another quarter of a turn, and place double the weight upon the next pin; and if the spring sustains that weight it is isochronal. If it does not sustain that weight, it shows that it will be too slow on the long vibrations, and be gaining in the short ones. Recourse must then be had to closing the cycloidal cheek at the stud, by which the spring, by being rapidly increased in tension, will have more dominion, and render the long vibrations quicker. A cycloidal cheek is produced by leaving the pin at the stud flat, and a little longer than usual.

The same object may be achieved by altering the formation of the upper curve or eye of the spring, uncoiling it and increasing the distance of the pinning in from the centre.

ON SPHERICAL SPRINGS.

Much has been said on the Continent in favor of spherical springs, but not much done with them (at least in this country).

They are much more troublesome to make than the helical, and are very difficult to adjust and set true.

ON BALANCE SPRINGS FOR POCKET CHRONOMETERS.

One obstacle that had for many years impeded the more general introduction of pocket chronometers was the want of sufficient room for a proper length of balance spring, as in short springs there was too much strain.

To obviate which, a very ingenious contrivance has been introduced in the shape of a double spring, a helical in conjunction with a flat spring; but for a pocket watch to stand any chance of obtaining the reputation of being deserving the name of a time-keeper, a very different plan must be adopted to what has hitherto been done; and no person can for a moment doubt that there is more elasticity and vivacity in two thin springs than in one thick one.

The motion of the body in walking tends greatly to disturb the vibrations of the balance, which is the divider of the time.

To diminish this evil, recourse must be had to giving the balance a quicker motion than what is generally done even with a train of 18,000, which may be effected by increasing the arcs of vibration at least to one turn and a half instead of the usual quantity of one turn.

The difficulty that has presented itself in the way of that most essential point of increased vibration, has been the want of a safe escapement, such as could not get the ruby impulse pallet broken off, which is frequently done (with the finest finished watches of the ordinary construction) in the act of winding, by giving the watch a rapid circular motion with the left hand while the key is being turned with the right.

To make a double spring, coil up twice as much wire as is requisite for the helical part of it to be made.

To make a double spring there is not so much trouble as many persons suppose, and when done it will amply requite the artist for his trouble. After it is hardened, tempered, and polished, uncoil what is not requisite for the helical portion, draw it out straight, and turn it up as usual for the flat spring, either by a spring winder or by hand, as has long been practised.

Another kind of double spring, generally known as the Breguet spring, has been found to answer the purpose extremely well, and is by no means difficult to make or render isochronal.

Take a full length flat spring, and after making an elbow at the outer coil, turn it by hand over the other coils; and form an eye or curve similar to that of a helical spring.

Another method of springing either box or pocket chronometers, is by the use of two springs either flat or helical, one above the balance and the other below it, and in contrary directions, so that while one is coiling up the other is uncoiling.

This introduces a most extraordinary and valuable improvement to the chronometer, inasmuch as it takes off (nearly) the whole of the side friction from the balance pivots, which is so destructive to the oil; the varying fluidity of which frequently occasions such unaccountable discrepancies in the performances of chronometers; and by the balance holes getting worn sooner than the others, the pivots get entirely cut off.

Isochronism is a subject upon which a most elaborate treatise (accompanied by mathematical demonstration) might be written, but whether the practical portion of the trade would feel disposed to devote the necessary time to read and enter fully into the spirit of it is doubtful.

I have, therefore, endeavored to condense the matter, and convey the particulars of the whole secrets in as few words as possible to render them intelligible, and for further information (to those who desire it) refer them to the valuable writings of Ferdinand Berthoud, Julien and Peter Le Roy, Paris, 1733 and 1773; George Attwood, Esq., in the Philosophical Transactions, 1794, Royal Society; Mr. William Hardy, in the Transactions of the Society of Arts, 1807; and Charles Frodsham, Esq., in the Horological Journal, Nos. 159 and 160, vol. xiv., November 1st, 1871.

The few memorable words of the author of chronometer springs (Dr. Robert Hooke), viz.: "Ut tensio sic vis," in English "As is the tension so is the force," contains the whole secret.

The particulars of which I will explain in as few words as possible, consistently with rendering the matter intelligible.

If the balance, in moving from the quiescent or point of rest to the extent of its vibration, acquires too much tension, it will gain in the long vibrations, and if it does not it will lose, and consequently gain in the short arcs.

To acquire the proper amount of tension is the subject for consideration.

The secret consists in the formation of the curves commonly called the eyes, and of their relative position to each other, pinning into the stud and collet opposite to each other as nearly as possible.

By opening or closing of the upper curve, making it larger or smaller, the equalizing of the vibrations can generally be obtained after a few trials and experiments.

To obtain a good chronometer at a tolerably cheap rate, recourse must be had to some new method of manufacture quicker than at present employed, particularly as regards the timing.

There is now much time wasted in equalizing the vibrations by isochronising the balance springs, and adjusting them for change of temperature, through the want of the means of calculation; which might be most efficiently effected by a few adjusting screws, but which is now done by hand, by bending and torturing the springs by sight and guess with the pliers, whereas, by proper tools, an alteration might be made upon them to an absolute degree of certainty, to less than the ten-thousandth part of an inch; for instance, by a screw with 100 threads to the inch, moved the 120th part of a turn round, which is very easy to be done.

The improvements that I propose are: firstly, the annealing of the wire; secondly, the use of round instead of flattened wire; thirdly, the application of two springs coiling and uncoiling in opposite directions, to avoid the side friction of the balance pivots; fourthly, adjusting for length of wire and form of curves, by means of fine screws of 100 threads to the inch, with large heads divided into 120, or an index divided into the same number, and operated upon by a pronged screw-driver with a pointer near its end; fifthly, the permanently setting of the springs by great heat after the final adjustments are made to them; sixthly, of the use of an adjustable cycloidal cheek at the pin in the stud, or several large-headed screws in the front of the cock, to touch against as it comes in tension, being neither more nor less than a cycloidal cheek; seventhly, an improved block to make the springs upon, whereby they can be hardened with the curves turned into their proper figure while soft.

If the proposed improvements which I submit for consideration are deemed worthy of being put to the test of further experiment, I shall be most happy to apply the greatest portion of what my essay may produce, to the advancement of the science of Horology, and the production of such models as are requisite to elucidate the matter clearly.

John G. Ulrich.

Treatise on the Isochronal Properties of the Balance Spring.

1st.—Different forms of springs at different times have been used for regulating timekeepers. In the year 1832 I purchased an old watch with a vertical escapement, with a fusee and piece of catgut instead of chain to wind it up; to regulate the vibrations of

the balance it had a turn and half of horse-hair and no curb pins, hence the term hair-springs used to this day; it was a twelve-hour watch; the nearest time I could get it to would be six minutes in twelve hours. Various forms of springs have been used for marine chronometers, double and single conical springs, double and single cylindrical springs, etc. A Mr. Simmons had one with three cylindrical springs for pocket watches. The volute or flat spring is most commonly used, and also the Breguet spring, which I believe is an improvement on the flat spring, where there is room sufficient for it to act freely. The late Mr. John Dent tried many different forms of springs; he used a glass cylindrical spring, that being liable to break in sudden changes of temperature did not answer; he also used gold springs, both cylindrical and volute, also steel springs, coated with gold; they were liable to corrode.

2d.—As regards the best method of obtaining isochronal properties, it requires a double spring, made and pinned in a peculiar way, by which means the arcs of vibration become equalized. In 1846, after many years of experience, and a large amount of money spent, I patented the duometrical or double cylindrical spring for marine chronometers, and double volute springs for pocket watches, and other time-keepers. The Astronomer Royal, seeing the action of the spring in a chronometer going, said, he considered the alteration a great advantage, the beautiful properties of isochronism were wonderfully developed with the double spring, and must be essential to the chronometer in keeping a good rate. All scientific men who have seen it admit the same.

Different escapements are more or less affected by the long and short arcs of vibration. The detent chronometer escapement, more than any other, though considered the best for correct time, I do not, from experience, admit it to be so. I chose my own patent escapement, it being not so expensive, much less liable to derangement, and quite as correct for measurement of time; having little or no rubbing surface, it requires no oil. The principle of my escapement is to give the impulse as near the line of centres as it is possible to give it. The first patent taken out, 1838, called the diamond lever escapement; the last great seal obtained, January, 1871. The vibration of the detent chronometer escapement, as I before observed, differs more than any other in the long and short arcs; hence the great difficulty of the springer is to set the turns of the spring and adjust the difference, and it can only be done effectually by the unison of two springs, by which means the arcs of vibration are equalized. Another important advantage gained is by keeping the chronometer balanced in the same position in all temperatures; consequently, the error caused by the expansion and contraction in different temperatures on the old principle, by which the rate of the chronometer was materially affected by the alterations of the beat, in my principle is totally eradicated, and which error no compensating balance could totally correct, and the chronometer, if properly made in other parts, becomes nearly a perfect instrument.

3d.—As regards the tools used for making springs, originally the flat springs were turned up by hand after the wire had been properly prepared as to strength and size. Some eight-and-twenty years since, tools were made with which to turn up the springs. I need not here describe them, as they are known by all, and very few flat springs are turned up by hand. Much more is required to make a cylindrical spring. I will now describe my own method; having obtained a piece of good brass, I turned it perfectly true, with a hole through it, making it a hollow tube; my wire being prepared the proper size and width, I have a groove cut the number of turns which I require for my spring; I then bind the wire tightly in the groove of the tool, making it fast at each end with a screw; it is then put in the fire and brought to nearly a white heat, care should be taken not to burn it; I always first rub it over with common soap, which prevents its scaling, and when quenched comes out nearly a white color. I quench it in oil or water, then draw it down to a light blue, and take it off the tool and polish it inside and out with fine emery; I then put it on another tool, taking care to put it on perfectly tight. I then bring it to a good color, when cold take it off the tool; it is then finished.

4th.—The method of pinning the common spring, I need not here explain. I consider springing it over the balance much the best principle, with springs turned up by tools. They are often much too close to get freedom

of action; in that case, if the spring be placed in a small tool covered with a piece of bright steel laid on the top of it, and gently heated until the piece of steel becomes blue, when cold and taken off the tool it will be found to have expanded to the size required. To pin my duometrical spring, I take my spring, say thirteen turns, breaking it in two equal parts; on the middle of my staff, between the balance and top pivot, I place a stud with two holes, I then put one end of each spring in the opposite direction to the other, I also make a stud to fix on the frame plate. I pin the other ends of the springs in the stud, care being taken that each spring is pinned perfectly true, both horizontally and vertically. Isochronal properties in balance springs as far as they can be obtained are very essential qualities. With the vertical, horizontal, and lever escapements, the vibrations are nearly equal, not so with a dead escapement. But again, your lever escapement is a very imperfect one, having so many parts in it.

To obtain true measurement of time, you should have a rest or stay to check any sudden oscillation that may arise from change of position or other causes. I make these remarks to show correct time-keeping depends materially on the quality and trueness of the escapement, even more than the isochronal properties of the balance-spring, though both are essential to make a good instrument.

To adjust the balance for different temperatures, the screws or weight of the balance are altered until you obtain the mean of the two extremes.

With the single spring, the expansion and contraction in different temperatures will alter the position of the balance; the effect will be an alteration of the beat, consequently an alteration of the rate if the chronometer be put in beat at a temperature of 60°; at 100° it will be found if set at rest, the arm of the balance pointing to 100°; at lower temperature, say 20°, the balance arm would point to 20°. If a chrononometer maker doubts this statement, I would recommend him to try and test it. I sacrificed some ten months in my trials to acertain the error. Having taken a brass plate, I planted two staffs, with a balance on each; I then put a single cylinder on the one, and a double one on the other, and according to the different degree of heat and cold, I marked the index on the brass by setting the balance at rest in each temperature. Now, it is quite impossible to eradicate this great error except by the arrangement of making the spring counteract its own faults. True, a good compensating balance may materially assist, and we can, in adjusting the weight, obtain the mean; but with the duometrical spring, much labor and time will be spared in rating the chronometer, and a uniform rate obtained in all temperatures.

I had forgotten to name the method of timing watches in different positions, but have fully described it in a paper published in the *Horological Journal* for March. The specifications of 46 and 52, with diagrams, showing the manner of pinning the duometrical springs, are in the library of the British Horological Institute.

G. C. Philcox.

Japanese Metal Working.

Until within a few years the Chinese, the Japanese, and East Indians were regarded in the light of barbarians; the mass of mechanics and artists little appreciating the fact that those same barbarians were, in many things, far in advance of our present skill, and that productions apparently in general and common use among them were beyond the power of our skill to produce. More general intercourse with these nations has begot a better acquaintance with their methods, and a more thorough appreciation of their mechanical abilities. In metal working they have shown an aptitude, and an appreciation of the capabilities of material, that ought to make us blush for our egotistical assumption and superiority.

Mr. John A. Audsley, who has studied Japanese art carefully, has given, in a recent lecture, some very interesting facts in regard to their artistic use of the metals. They are particularly expert in casting, carving, damaskeening, engraving, weaving, and tempering metals. In many of these departments are shown specimens comparable to any produced in Europe. In the most characteristic of their metallurgic works there is an association of numerous metal alloys producing designs in colors through the agency of the various colored

metals; white being represented by silver, yellow by gold, black by platina, all shades of dull red by copper and its alloys, brown by bronze, and blue by steel. To represent a red garment, embroidered with gold, and clasped with silver, it would be executed in red copper, inlaid with gold, and furnished with a silver broach. The sword in the hand of a warrior would be of polished steel, and, if bloody, would be inlaid with red copper. These instances illustrate their mode of producing colored designs by the exclusive use of metal.

The Japanese have also brought bronze casting to a great degree of perfection. They produced highly finished polished bronze work in relief, which is produced by cutting the surrounding metal away, and the relieved objects are then engraved and richly damaskeened with gold and silver. Even in bell founding, art is never neglected in their designs. Flat silver wire, woven into various patterns, is a favorite material for covering uniform surfaces, and is generally applied by Japanese artists in a very effective manner, and they have been quite as appreciative as Western silversmiths in the correct method of working metals. In a group of storks every feather is a thin plate of metal, carefully engraved, the legs, tails, necks, and heads of the birds being in their natural colors; the rock they stand on is modelled with accuracy, and the vegetation truthfully rendered. Often the highest recommendation of our artists is that their productions contain so many pounds of "solid silver."

——o——

A Few Words About Friction.

Ed. Horological Journal:

This subject, which has been so fully discussed by some of your ablest contributors, did seem to me to be waning in interest until a short time since a friend of mine in Baltimore, who, by the by, is a first-class workman, astonished me by producing a rather ingenious instrument for the solution of the problem. I muttered as I left the store, the last words of Daniel Webster, it "isn't dead yet." In fact, the laws of friction have never been completely discovered. The results have been classified, so far as we have the means of judging them, but they are necessarily inaccurate. I am not astonished, then, at one of the controversialists changing sides in the course of the discussion, nor would I be astonished if in the course of time, in the pursuit of his investigations, he should find himself back on the side from which he took the "departure." The principles which underlie friction must be understood before the results can be arranged under specific laws. Friction is a result of other forces. Here I am not so sure but that I am on ground which, to science, is a *terra incognita.* In all human productions there must be imperfections, because the producing power is imperfect. I mean by that that there are limits to our powers on all sides and in all ways; the mind itself being alike unfitted for the contemplation of the infinitesimal and the infinitely great. The point of the finest cambric needle displays under the microscope a rough, jagged, uneven surface. The sting of a bee, on the contrary, still tapers out to an imperceptible point. To the watchmaker this imperfection of mechanism is perfectly plain, for this reason, that he is almost constantly adding to his powers. His eyes are helped by glasses, and the senses of touch and sight are magnified by micrometrical gauges and calipers. Science and art are furnishing multiplying aids. Brains certainly will command a higher premium today than in the palmiest days of Berthoud and Hook, Harrison and Graham. The ideas of American mechanics *are machines* which employ a thousand hands. Each idea is born a "Briareus," and seems to have a hundred heads as well as a hundred arms. But what, in horology, is all this for? To produce finished mechanism. Why all the work employed in stoning and polishing the pivots and jewels of watches? *To reduce friction.*

There are certain conditions, then, which increase friction proper, and this may assist us in our investigation. The greatest friction is produced by the most uneven or rough surfaces, as these rough surfaces are the obstructions in the path of a moving body. If in a circle, they are protuberances over the line of a mathematical circle; if on a plane, protuberances over a mathematical circle. If these obstructions are removed by the moving body, we call it abrasion; if not, the body is forced out of its true course, and the body is lifted or pushed up inclined planes of various angles

according to the material. This is the chief difficulty in friction. The great aim of polishing is to reduce these protuberances or obstructions in the course of pivots. But, suppose the process of polishing could be carried to such a degree of perfection that the primary atoms only remain to present these obstructions or protuberances beyond the mathematical line or circle; still there would be friction, for these cannot be changed. Oil lessens friction by introducing its own globules, which, being round or oval, and not being so much affected by another force, which I will mention, move freely on each other. Oil serves this purpose the better, the less liable it is to change; the character of these globules, by evaporation, becoming solid by cold or viscid by use.

Various metals produce different friction by the different character of the atoms or crystals forming their composition. Now, the question in dispute is really this: Whether a long bearing, engaging more of these points or protuberances, with the weight equally distributed among all, will present more obstruction to the true circle or plane, than a short bearing with the same weight equally distributed among its protuberances; that is, whether it will take more power to carry 1,000 pounds over one hill, than it will take to carry 500 pounds over two hills. There are other circumstances, however, which affect these results. This view alone would give us no difference between a long and a short bearing. In each one of the cavities formed, will be a small increment of air, which, in themselves, will not affect, by their elasticity, the result just shown, since the elasticity, under different pressures, is, to all practical purposes, regular. These particles are, however, themselves subject to the principle I now state, but will make a variable result in the influence of molecular polarity; since it has been determined that the ultimate particles of all matter have electrical poles, and are invariably arranged north and south.

I have been led to think that attraction of cohesion proper was, in great part, the result of this electrical arrangement of the atoms; especially since it has been discovered that the attraction of cohesion is lessened by the derangement or vibration of these poles by the application of heat, in proportion to the degree of that heat. By the way, would it not be singular if, after all, the whole frame of nature, and, so far as we are concerned, all time, should be held together by electricity? I think I should emblazon my Horological banner with "Electricity Forever." But these electrical influences do affect friction more or less. In long pivots these poles, being more numerous, would present more obstructions in the breaking of the connections; but again, the compression of these cushions of air, oil, etc., would bring them in closer contact in proportion to the shortness of the bearings, the weights being equal. There are other constituents which go to make up the sum total which we call friction, but these are the leading points.

For myself, not being yet fully decided in regard to all the points involved, I can not say whether I am for the long or the short pivots. During the controversy, as I took up the subject for a little change of thought, first I would be on one side, then some new point would be evolved and I would be on the other side; and it was a little amusing to think that, when one of your correspondents, wishing to save his mechanical reputation, came out very penitently and confessed his sins, I had just changed to the place he left. I said to myself, "Change off." I think the best plan is to make pivots neither too long nor too short; and I think the hollowing or curving the ends of pivots, for the purposes of adjustment, will be used successfully for a long time yet, for there are other laws involved that I have not enumerated.

J. C. HAGEY.

Abingdon, Md.

Long and Short Screw-Drivers.

ED. HOROLOGICAL JOURNAL:

Although an investigator in the region of pure, and not of applied science, I take the liberty of adding a few remarks to the articles which have already appeared in the JOURNAL, discussing the relative efficiencies of long and short screw-drivers, and I hope that I will not thereby "darken counsel with words."

The *fact* that a long screw-driver will force a screw with greater effect than a short one, I consider as established by all experience, and readily proved by the following method: Take two drivers, having their handles of the same diameter and with their noses of the same

breadth, but of different lengths; into a block of wood force a screw with the short driver until no further effort will turn it. Now take the long driver and hold its length *exactly in a line with the axis* of the screw, and endeavor to drive the screw deeper. It will be found that it is not, in this position, more powerful than the short driver. But now *incline the long driver away from the axis* of the screw, and the driver will move the screw, for you have now added to the radius of the handle the half diameter of the circle the handle of the driver describes when you cause it to rotate when inclined to the axis of the screw.

If any one will notice carefuly the motion of his hand and wrist when he uses a driver, he will observe that in making it rotate he naturally swings the driver out of line with the axis of the screw, and thus unconsciously increases the leverage which the handle gives when held alone in the axis of the screw. With a long driver this inclination can be, and generally is, greater than with a short one; for in the latter case a slight inclination causes the nose of the driver to slip out of the screw-head.

The following experiment will convince any one that the above explanation is at least worthy of respect. Place a block of wood on the floor and in it drive a screw until it is steady; now take a long driver, incline it away from the screw and walk around the screw, keeping the driver always inclined, and you will force the screw with great effect without ever turning the handle in your hand.

This experiment on the drivers were made and confirmed by myself and by two mechanics independently of each other. I merely told them how to operate the drivers, and their reports corresponded with my experience. PHUSIS.

Stevens' Institute of Technology,
Hoboken, N. J.

Answers to Correspondents.

T. B., *Mass.*—The mechanical device you inquire about is, like every other "mystery," simple enough when understood. The "horse timer," on which you saw the second and minute hand return from any part of their revolution to 60 by means of a stop, is a very simple use of a heart-shaped eccentric cam which is attached to each hand separately. The sweep-second from the centre, and the minute-hand revolving in a separate small circle, both slip spring-tight upon their respective pivots by means of a long socket, upon the lower end of which, under the dial, there is fixed a small, heart-shaped cam; of course, these cams revolve with the hand when left free. To return the hand to 60′, there is a branched arm secured by a repose screw to the plate of the movement, and lying in the same horizontal plane as the cams; this arm has the end of each branch so shaped, that when pushed into contact with the cams, they are forced to revolve about the pivot till in such position that the point of each arm rests in the notch of the heart, the hand being so fixed that it points to 60′ so long as the cams are held in that position; the moment the arm is withdrawn, the whole starts upon its revolution by frictional contact with the pivot which carries it.

From the peculiar shape of this cam, it is evident that the return of the hand to 60′ may be either direct or reverse, depending upon the position of the point of the heart at the instant the arm is brought into action. This same principle is susceptible of many useful and ingenious modifications, and is much used in the various forms of stop-seconds, chronographs and other time-marking instruments.

J. P. W., *Bradford, Ont.*—Your experience with Kelley's oil upon main-springs is different from the majority of the trade, and we do not see why *any* oil should have "a tendency to break main-springs." Of course all the subtle, unseen influences of nature are not known to us mortals; but from what we do know, we can see no reasonable connection between this cause and effect. Are you quite sure that your suspicions have been confirmed by carefully observed facts? It is possible that some such process of refining as that used for petroleum, would leave traces of the acid used, which might corrode the steel of the spring so as to cause breakage; but such a condition would be shown by the general appearance of the spring on its whole surface. From what we know of Mr. Kelley's method of purifying his oils, such a result is not possible. The best artisans use by preference clock oil for

main-springs, for the reason that it has rather more body than the limpid watch oil, and better withstands the pressure of coil upon coil. The fault is more frequently committed by using too much oil upon main-springs than too little; in fact, the least possible amount of oil is the best, drawing the spring through an oiled rag being amply sufficient. We suspect that were you to select some other oil than Kelley's, and use it alternately upon new springs, keeping a memorandum upon your watch-book of the kind used, you would find quite as many of one sort return broken as of the other. The experiment is worth trial by others as well as yourself.

E. L. M., *Defiance, O.*—Cyanide of potassium dissolved in water is the usual method of cleaning tarnished brass. Give the article an instantaneous dip, wash with clean water, then with alcohol. If the article remains in the bath too long, the high polished surface becomes deadened, and loses its gloss. Chronometer balances are thus instantaneously cleaned. They may be dipped in the bath just as they are, without removing the hair-spring, and if carefully washed and dried off by alcohol no danger need be apprehended. The plates and wheels of French clocks and music boxes are quickly done in the same way; in fact, any tarnished brass work. Never mind, Brother M., you are not the only one at whom empty heads are wagged; those who will tell you nothing, because they know nothing worth the telling.

F. S., *Long Island City.*—A long back fork (guide or crutch) has no more power to move a pendulum than a short one. In the class of electric clocks you speak of, where the pendulum gives motion to the movement, it meets with the same resistance from the back fork whether it be a long or a short one, but a long back fork has this advantage: If its centre of motion is not on a line with the centre of motion of the pendulum, there is less sliding friction at the point where the fork acts upon the pendulum when the fork is a long one than when it is short.

G. M. A., *Kansas.*—The African diamond mines have produced great quantities of stones, of which the majority have been large ones, and have generally been found on the surface of the ground, giving but little trouble to the miner, and thus yielding a more profitable return for the capital employed in diamond mining in this region than in the mines of Brazil. It would probably be more proper to speak of this locality as diamond fields rather than diamond mines.

The majority of stones found are "off color," and the market value has been affected to a considerable extent; but as the number of fine stones is so small in proportion to inferior qualities the former command as high a price as the favorite "old mine" diamonds. It would be difficult to describe the peculiarities of the African diamonds, but experts claim to be able to detect them at a glance. Many of them have a perceptible tinge of green. We have seen, in the stock of Messrs. Randel, Baremore & Co., the well-known diamond importers, brilliants of every shade of color, from the deep yellow to the finest white, or first water, and of a brilliancy equal to any diamonds known. The Arizona mines are, as you have probably already learned, a fraud.

M. B., *Luzerne Co, Pa.*—There is no way by which you can restore the red color of alloyed gold, which has been changed by heat, except by repolishing; use rotten-stone and oil, then finish with rouge. The yellow color you complain of is a thin film of fine gold on the surface, from which the alloy has been removed by oxidation in the fire and by the process of pickling or boiling out, to remove the oxide. Something can be done to somewhat prevent this by protecting the article from contact with the air, by a coating of paste made of yellow ochre and water.

W. P. F., *Wisconsin.*—You will often be able to get an obstinate joint pin out of a broach by setting the end of the joint upon the square corner of a lead block, giving the pin a smart blow with punch and hammer; if the first attempt does not start it, set it on a fresh spot and try again. This lead block is a most useful stake to have upon the bench. A cube two inches square is easily cast, and will be in almost constant use for punching holes, driving on hands, and the thousand and one little jobs that require a firm and solid, but yet yielding support. Of course they soon get battered up, but can be reformed by casting in a paper box, and the corners and faces are again fair and square.

It is possible that the trouble you have experienced arises from the use of a bad punch; you can adopt no surer way of effectually riveting in the joint pin, than to attempt to drive it out with a punch a little *rounded* on the face. It should be perfectly square, and the full size of the pin; no practice is more reprehensible than the use of one or two punches for *all* jobs; neither is it excusable, because they are so easily made of waste files, broaches, etc., that otherwise litter up the bench. There is no need to tell how one should be made, except to say that only the extreme end should be tempered, and it should be kept perfectly flat on the face; with such a punch of the proper size for the job in hand, almost anything can be driven out.

J. S., *New York City.*—The inflation of the currency, and the consequent abundance of money during the early years of the war, had the effect of creating a great demand for watches, and doubtless gave a great impetus to the development and establishment of watch manufacture in this country. It is an open question as to whether the high protective tariff advocated by the late Horace Greeley tended to produce similar results. Mr. Greeley was certainly a great and a good man, but it is not within the province of this journal to enter into the discussion of questions of political economy.

G. L., *Boston.*—The discussion on the friction question is by no means exhausted. Our correspondents manifest as lively an interest in the subject as ever. The late silence on the subject is ominous of further controversy. Our correspondent, Clyde, has promised a communication on the subject for the January number.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For January, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be added to Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Wednesday	1	71 05	3 59.08	1 182	18 44 49 08
Thursday	2	71 01	4 27.25	1.167	18 48 45.64
Friday	3	70.96	4 55 03	1.150	18 52 42.20
Saturday	4	70.91	5 22.41	1.132	18 56 38.76
Sunday	5	70 85	5 49.35	1.113	19 0 35.31
Monday	6	70.79	6 15.78	1 093	19 4 31.87
Tuesday	7	70.72	6 41.73	1.071	19 8 28.43
Wednesday	8	70 65	7 7.14	1.048	19 12 24.99
Thursday	9	70.58	7 32.02	1.024	19 16 21.55
Friday	10	70.50	7 56.30	0.999	19 20 18.11
Saturday	11	70 42	8 19.99	0.975	19 24 14.66
Sunday	12	70.34	8 43.06	0.949	19 28 11.21
Monday	13	70.25	9 5.49	0.922	19 32 7.78
Tuesday	14	70.16	9 27.27	0.895	19 36 4.34
Wednesday	15	70.07	9 48 40	0.867	19 40 0.89
Thursday	16	69.97	10 8.86	0.838	19 43 57.45
Friday	17	69 88	10 28.62	0.809	19 47 54.01
Saturday	18	69.78	10 47.67	0.770	19 51 50.57
Sunday	19	69 68	11 6.01	0.749	19 55 47.12
Monday	20	69.57	11 23.64	0.719	19 59 43.68
Tuesday	21	69.46	11 40.51	0.688	20 3 40.24
Wednesday	22	69.35	11 56.63	0.656	20 7 36.80
Thursday	23	69.24	12 12.00	0 624	20 11 33.35
Friday	24	69 13	12 26.59	0.592	20 15 29.91
Saturday	25	69.02	12 40.39	0.559	20 19 26.47
Sunday	26	68.91	12 53.41	0.526	20 23 23.02
Monday	27	68 80	13 5.62	0.492	20 27 19.58
Tuesday	28	68.68	13 17.02	0.459	20 31 16.14
Wednesday	29	68 57	13 27.59	0.424	20 35 12.69
Thursday	30	68.45	13 37.34	0.389	20 39 9.25
Friday	31	68.34	13 46.28	0.354	20 43 5.81

Mean time of the Semidiameter passing may be found by subtracting 0s.19. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

	D.	H. M.
☽ First Quarter	5	9 27.5
☺ Full Moon	13	4 23.0
☾ Last Quarter	21	8 30.8
● New Moon	28	5 27.2
	D.	H.
☾ Apogee	15	13.8
☾ Perigee	28	13.4

Latitude of Harvard Observatory .... 42° 22′ 48″.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION.		APPARENT DECLINATION.		MERID. PASSAGE.
	D.	H. M. S.	° ′ ″		H. M.
Venus	1	21 40 1.37	−15 50 52 1		2 55.3
Jupiter	1	10 14 4.05	+12 4 4.2		15 26 6
Saturn	1	19 35 54.69	−21 39 17.8		0 51 0

AMERICAN

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CONTENTS.

ESSAY

ON

WATCHMAKERS' REGULATORS, WITH PRACTICAL DETAILS FOR THEIR CONSTRUCTION.

BY HENRY J. N. SMITH.

CHAPTER I.

INTRODUCTION.

Of all the instruments used by a watchmaker in the prosecution of his business, there is probably none more important than his regulator. Its purpose is to divide time into seconds, and it is the standard by which the practical results of his labors are tested; the guide which all the other time-keepers in his possession are made to follow, and the arbitrator which settles all disputes regarding the performance of his watches.

No regulator has yet been constructed that contains within itself every element for producing absolutely accurate time-keeping. At intervals they must all be corrected from some external source, such as comparison with another time-keeper, the error of which is known, or by the motion of the heavenly bodies when instruments for that purpose are available. Before beginning to make a regulator, the prudent watchmaker will first reflect on the various plans of constructing all the various details of an accurate time-keeper, and select the plan which, in his opinion, or in the opinion of those whom he may consult on the subject, will best accomplish the object he has in view.

MOTIVE AND REGULATING POWER.

Two primary questions, and which must be decided at the very beginning, are whether to use a weight, a spring, or electricity, as a motive power; and whether to use a pendulum or a balance in conjunction with a spring to regulate the motion of the time-keeper.

If the proposed regulator requires to be a portable one, like a chronometer, then the use of a spring for a motive power, and a balance and spring for a regulating one, becomes an imperative necessity. If, however, there is no special object to be gained in making the time-keeper a portable one, and if it be decided to make it stationary, then in such a case it must be admitted that a weight has advantages over a spring as a motive power, and that a pendulum is superior to a balance as a regulating medium.

Ever since the introduction of the electric telegraph, electricity has been used in various ways as the motive power to maintain the vibration of clock pendulums. The greatest advantage gained by using electricity for this purpose is that the clock requires no winding. For clocks placed in unaccessible positions this is a great benefit, and it is also a convenience in several other respects; but a watchmaker's regulator is generally placed in a position that is easy of access, and the watchmaker himself is always in attendance to wind up other clocks and watches which may be in his possession, therefore it is neither a trouble nor an inconvenience for him to wind his own clock; and for the object we have at present in view, we should use a weight, to be wound up by hand at stated intervals, as being the most

simplo and reliable method of obtaining a motive power.

If desirable, we can use electricity with great advantage, in conjunction with our regulator, to move the hands of a secondary dial, placed in a window, or on the front of a store, or in any other situation. With all the different parts properly constructed, the hands of the secondary dial will follow those of the regulator with the greatest precision, while the rate of the standard time-keeper will not be disturbed in the least degree.

TENSION *versus* GRAVITY.

We are aware that the advocates of the use of a spring as a motive power, and a balance, in conjunction with a spring, as a regulating power, have some good arguments to support their views. The strongest of these arguments is Dr. Hooke's pithy remark regarding springs, which has now become a proverb. "As the tension, so is the force," said this great philosopher; and we believe that the truth of this familiar remark of his regarding springs cannot be contradicted, and from which we must infer that the strength of a balance-spring or a main-spring is always equal to their tension. There is, however, considerable difficulty in making a spring that will always retain the same tension; and when the tension does happen to vary, the strength must also vary, agreeably to Dr. Hooke's rule.

Natural Philosophy teaches us that the power obtained by falling weights varies in proportion to the size and density of the weights, and the length of the space through which they fall. However, a weight of a given size and density, falling through a given amount of space in a given latitude, will always exercise the same amount of force under every variety of circumstances. From these well-known laws we learn that the force of a weight cannot vary, while the force of a spring, being equal to its tension, will sometimes vary, because the value of the tension will sometimes vary. The action of gravity on a pendulum is precisely the same as it is on a weight; and for this reason, as also on the ground of cheapness and simplicity, we would prefer a weight for the motive power, and a pendulum for the regulating medium, for all stationary clocks, when the design of their cases affords sufficient accommodation to use a pendulum and a weight to advantage.

DEFECTS IN REGULATOR CASES.

In former years a regulator case was made with the sole object of accommodating the requirements of the regulator, and every detail in the construction of the case was made subservient to the necessities of the clock. The plain, well-made cases of former years are now almost discarded for those of more pretentious design. If the general change in the public taste demands so much display, there can be no objection. It is perfectly harmless to the clock if the designers and makers of the cases would only remember that narrow waists or narrow necks on a case, although part of an elegant design, do not afford the necessary room for the weight and freedom of the pendulum; that the doors and other openings in the case must be constructed with a view to exclude dust, and that the back should be made of thick, well-seasoned wood, so as to afford the means of obtaining as firm a support for the pendulum as possible.

When a regulator case is known to have been made by an inexperienced person, which sometimes happens, it is always the safest course for those who are intrusted to make the clock to examine the case personally and see the exact accommodation there is for the clock. Sometimes, when we know beforehand, we can, without violating any principle, vary the construction of the clock a little, so as to make the weight to clear the woodwork of the inside of the case, and in other respects complete the regulator in a more workmanlike manner by making the necessary alterations in the clock at the beginning of its construction, instead of after it has been once finished agreeably to some stereotyped arrangement.

ARRANGING THE HANDS ON THE DIAL.

Another primary question which must be decided at this stage is, how shall we arrange the hands on the dial? Figure 1 represents the most familiar method of making a dial for an hour, minute, and seconds hand. The hour and minutes hand move round the large circle, and the seconds hand on the smaller one. In clocks for ordinary use, where reading the hours and minutes is of chief importance, this

style of dial is probably the best; but in a regulator the distinct reading of the seconds hand is of greater importance, and this style of dial is not so well suited for that purpose owing to the small size of the seconds circle. Figure 2 represents a dial where the hour, minute and seconds hand all move around one circle. This plan is sometimes adopted in a certain class of regulators, but it has several disadvantages.

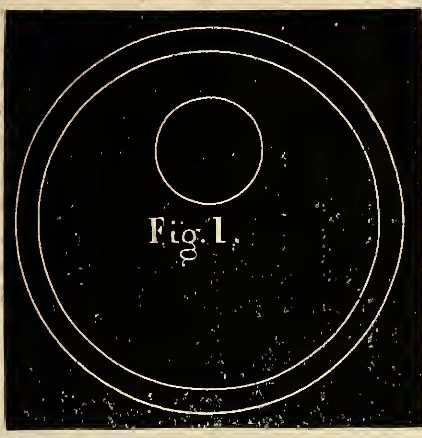


Fig. 1.

The arrangement of a movement to suit a dial of this description is not so favorable to accurate time-keeping as is desirable, and the three hands, moving from one centre, have a confused appearance, while the object aimed at in arranging the hands ought to be distinctness of perception, so that the time the different hands

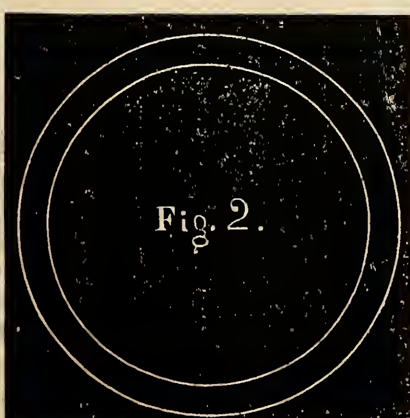


Fig. 2.

point to may be read accurately without difficulty. Figure 3 represents the method of arranging the hands mostly used on astronomical clocks and fine regulators. The seconds hand, which in this class of clock is the most important, moves on a circle of its own, which is arranged to be as as large as possible, while the minute and hour hands have separate circles, and which are engraved in such a manner that the position of all the hands may be read at a glance without difficulty. Another advantage of this arrangement of the hands is the opportunity it affords of constructing the movement in the way best adapted to insure reliability and simplicity.

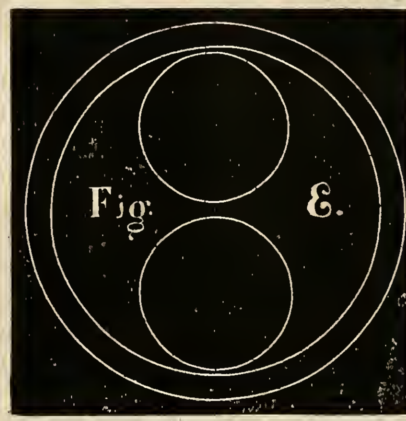


Fig. 3.

Figure 4 represents a form of a dial which is favorable to the construction of as simple a movement as the dial last mentioned, and it is probably the most clear and distinct arrangement for a dial that is in use. The hour circle, which is of minor importance in a regulator, is suppressed, and the hours are engraved on the

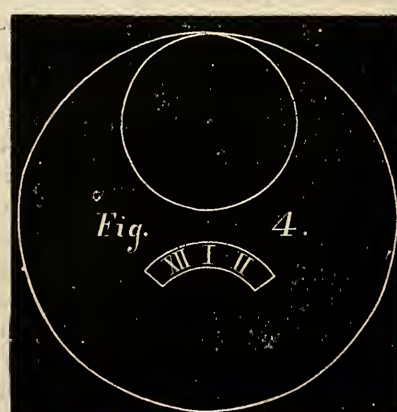


Fig. 4.

front of the hour wheel, which is arranged to work near to the back of the dial, and the figures show through an opening made for the purpose, as is shown in the diagram.

The seconds circle is large and distinct, while the size of the seconds hand is not so great as

to be a burden on the scape wheel axis to the same extent as a centre seconds hand is.

ON THE LENGTH OF TIME THE CLOCK SHOULD RUN WITHOUT WINDING.

It is a difficult matter to determine exactly the length of time that a clock should be made to run without winding. Some clocks are wound up every twelve hours, and others only once in a number of years. As a rule we give the preference to those that are wound up at moderately short intervals, because they are more simple and less liable to error than those that run a long time without winding. If we suppose that the force that is necessary to turn the centre wheel of a regulator round once in an hour is equal to one grain, then, without allowing any thing for friction, it will take the force of 24 grains to turn the wheel 24 times; a force equal to 168 grains to give the necessary number of turns for 7 days, and 8,760 grains for 365 days. As much or probably more than one-third more force must be added for the waste of power caused by the friction of pivots, and the teeth of the wheels working on the pinions, and from the imperfect workmanship that exists in a greater or less degree in all time-keepers.

From the above example it will be seen that a clock can be made to run for any length of time by increasing the number of teeth in the great wheel, or by multiplying the number of wheels and pinions between the great wheel and the centre pinion, and increasing the size of the weight in the same proportion. And it will also be seen that the chances for error from imperfections in the shape of the teeth of the wheels and leaves of the pinions, and from variation in friction, increase in the same ratio that the number of turns are multiplied. We see this illustrated in practice every day. An eight-day chronometer is never so reliable as a two-day one. An eight-day watch always gives more trouble to all concerned than a thirty-hour one, and a common eight-day clock stops more readily than a thirty-hour one, should there be any defects about the wheel work.

But while the time-keeper that requires to be wound up the oftenest is the most likely to run the best (everything else being equal), yet the necessity for frequent winding increases the risk of disturbing the rate while in the act of winding, if the maintaining power does not act perfectly, and the risk of the time-keeper's running down and stopping altogether is also increased by the necessity for very frequent winding; therefore we should select a medium between long and short periods for winding. In a regulator with a seconds pendulum there is usually sufficient room in the case for a weight to work effectively for a short period, and the clock may with great propriety be constructed to be wound up every week. The beginning or end of a week is a period one is most likely not to forget, and probably, to take it all the year round, it is not so liable to be forgot when winding regularly every week as it would be at the interval of a month. When regulators are made with the tallest class of cases, perhaps it would be an improvement to construct them to run nine or even ten days in place of eight. This arrangement would allow two or three days' grace, in place of one, should the clock be neglected to be wound at the end of the seven days, while the chances of error by the slight increase in the number of teeth in the great wheel, or by slightly reducing the diameter of the barrel, or increasing the number of its turns, would be trifling.

[TO BE CONTINUED.]

Watch Repairing.

NUMBER SEVEN.

BY JAS. FRICKER, AMERICUS, GA.

We treated of the centre wheel in our last article, and, in accordance with our first idea, we shall continue on the "train" until we come to the escapement.

If a new centre pinion is to be put in, select one with the right number of teeth first, then get the size from the old one with a pinion gauge, or, what is still better, use one of the Swiss dial gauges, which will give more accurate measurements; and for a scape pinion, for instance, too much care cannot be exercised in selecting one of the proper dimensions.

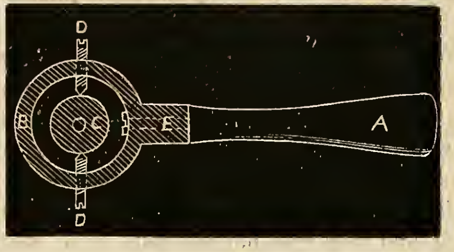
Having selected a pinion, cement it up on the lathe, and true it up by the outside of the leaves; when it is cold, make a good centre on the projecting end; reverse it, and again true up by the outside of the leaves. If the old centres

were very much "out of centre," you will have to again reverse it and true up by the outside of the leaves. The reason for this is, upon a little reflection, very manifest; yet how few ever think of it, or take the trouble to get the centres in this way. We have very frequently found, on putting a pinion up in the lathe and truing it up by its pivots, that the outside of the leaves were not concentric with the pivots; and this, too, in watches that were not considered poor watches either, and new work at that.

If you have the old pinion for a guide, you can with but little trouble get your distance in the new one. We usually fit in the upper pivot, and get the body of the pinion the right length, and mark about where the centre wheel will come, then polish the staff portion of the pinion same as for the fuzee pivots. Now comes the terror of all inexperienced workmen who are anxious to do good work but don't know how; that is, to "face up" the pinion. It is a very easy and simple process, but can be done with a "bow" better than in the lathe. Clean the shellac all off from the pinion, and put on a screw collet. If you have no polishers, proceed to make some at once, as follows:

Take a piece of sheet steel, say ½ or ¾ of an inch square, make it slightly convex on one side by means of a large round-ended punch; lay the piece of steel on a block of lead and hammer it or force it into shape with your punch; drill a hole in the centre slightly larger than the staff part of the pinion, and with a flat file file the convex side just sufficient to make a flat place large enough to cover the ends of the leaves; apply some oil-stone powder and oil on your polisher, insert your pinion staff (having put on the drill-bow), hold the steel polisher or grinder rather loosely with the fingers of the left hand, and with the other end of the pinion in one of the holes of your vice work it back and forth just as if you were drilling a hole. As soon as the grinder gets smooth, file up again, always bearing in mind that the oil-stone powder only acts while the grinder is rough. As soon as you have got a good flat smooth surface on the end of the pinion, clean it off and use a polisher made of bell metal, just like the steel grinder, using not less than two grades of crocus; then a copper polisher and very fine crocus will give a fine gloss. To get the "black" polish so much admired in fine work requires some little time, and the use of several grades of polishing stuff. Always clean off every particle of the last used powder before using a finer grade, otherwise you may have your work all to go over again, as one particle of coarser powder mixed with a finer grade will make a scratch that takes time to remove with a coarser grade than the one you are using when the scratch occurs.

Mr. Royal Cowles, of Cleveland, Ohio, uses a very neat little tool for facing up pinions, which must be a good thing, although we have never used it; for the benefit of those who would like to make one for themselves, we give a drawing sufficiently accurate to enable any one



to construct one. A is the handle, either of wood or metal; B the outer disk, which need not be over ¾ in diameter; C the inner disk, or polisher; D screws with a centre on the end of each; E the joint or collar connecting the outer disk to the handle. If the handle is wood, a piece of brass or steel must be fastened in the end of it, turned down with a square shoulder for about ¼ of an inch, which just fits into the collar of the outer disk, which can be held on to the handle by means of a screw, as shown in the cut, which allows the disk to freely revolve on the handle; the two screws passing through the rim of the disk, the points of which enter the centres in the edge of the polisher, enables the polisher or grinder to revolve in the opposite direction to that of the outer disk; working, in fact, on the principle of "gimbals," such as are used for ships' chronometers and compasses.

The disk being properly prepared is applied just the same as in the other case. This instrument enables you, without any trouble whatever, to make and keep a flat surface on the pinions. Some use, instead of the flat disks of steel first mentioned, steel wire; to make which, drill a

deep hole in the end of a piece of steel wire that is slightly larger than the pinion, and you have your grinder. These are easy to file up and keep in good order for grinding or polishing, either of which will answer; some prefer one, and some another, but with care you can do as good a job with one kind as the other.

Having finished up this end, put up in the lathe and fit on your wheel and turn and finish up the other. After having riveted on your centre wheel, as directed in former article, polish up the "hollow" on this end of the pinion just in the same way as you "faced up" the other end, only you will require *convex* polishers and grinders. For this purpose you will find the steel and brass wire grinders and polishers the kind to use. The end can be finished up very nicely while in the lathe by the same process as that of polishing the "hollow" of the fuzee.

Whenever you put in a new pinion, and are going to use the same old centre wheel, see if the teeth are worn much. If so, put it on the other side up, when you put it on again, and always, whether you reverse it or not, put it up on the lathe, truing it up by the outside of the teeth, and then true out the hole, as no watch can perform satisfactorily unless the outer extremity of the teeth of wheels and leaves of pinions are concentric with the pivots. Too little attention is paid to this by a majority of workmen.

Some will say, what is the use of all this work on the face of the pinion, as the owner never never sees it, and no action takes place there? Now all will admit that it certainly looks better, which is one reason; next, all ought to know, if they don't, that dirt and dust will not accumulate and stick to a piece of finely polished steel as it will to that that is rough, which is another good reason; and furthermore, if you will only take the pains and trouble to face up your pinion properly you will be very certain to do the rest of the work properly, which is a very important reason. Now, here are three good reasons for facing up a pinion, and not one good reason can be given why it should not be done.

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☞ In the February number we expect to present an article on the Angles of Tools, by Prof. Egleston, of Columbia College.

Mr. John G. Ulrich's Essay on the Balance Spring.

In this number we give the first part of Mr. Ulrich's Essay, which we were compelled to omit last month for want of space, and hope soon to be able to present the other Essays offered in competition.

ON THE ORIGIN OF THE BALANCE SPRING.

From the middle of the twelfth century to the year 1658 very creditable pieces of clock and watch work were made with the vertical escapement, but without a balance spring; a beautiful specimen of which is to be seen at the Antiquarian Museum, Somerset House. It was made, apparently in Germany, for Sigismund, King of Poland, about the year 1525.

The attention of the justly celebrated Dr. Robert Hooke, F. R. S., was first attracted to the subject of improvements in the science of Horology for the purpose of being able at all times to be certain of surely knowing the correct Greenwich time at sea, for ascertaining the longitude.

Previous to the year 1648 the attention of Dr. Robert Hooke was directed to ship building, and he constructed a vessel about three feet long, fitly masted and rigged, and armed with two small guns that could be discharged on its passage over a miniature lake.

His next attention was devoted to devising means for conducting ships safely and more expeditiously over the trackless ocean by more correct methods of navigation than were then known, and with some tolerable degree of certainty, which was surely knowing the Greenwich time when at sea so that he might ascertain the ship's longitude. But to get and preserve the Greenwich time at sea was the difficulty; hence the discovery of the chronometer spring, and various other things in the science of Horology.

That he was well aware of the importance of steam power is manifest from the secrets he imparted on the subject to his friend Mr. Newcomen, (viz., "that the air presses with force the vacuum left after the use of the fire,") a frequent visitor to him at the Royal Society, who was the first to get the steam put in practice; and who was soon followed by Captain Savory, Watt, Stephenson, and others.

The first essay of Dr. Hooke towards the production of that grand desideratum a time-keeper, was an invention for equalizing the force of the main-spring by the introduction of a geometrical cone (now called a fuzee) for a line, or chain, to be wound upon from the barrel—the box containing the main-spring.

Seeing that a balance would be subject to continual irregularity of action through the ship's motion, his next step was to contrive a time-keeper with two balances moving in contrary directions by the aid of toothed wheels, to counteract the irregularity of each other. He also contrived several kinds of dead beat escapements, one of which was the duplex, although not exactly as we have it now. These would not go without a spring, which he quickly contrived, and placed round the axes of his balance.

His next difficulty was with the friction of the wheel work of two balances, when he directed his attention to various arrangements and forms of his springs to acquire sufficient extra tension to cause the long vibrations to take place in the same time as the short ones.

Having discovered the means by which he could make the long and short vibrations to take place in the same time, he gave public lectures on the subject. I subjoin an extract and some remarks from his Cutlerian lectures, No. 11, page 69, published by the Royal Society, 1878 :

"In order to bring this treaty to pass, I was necessitated to disclose something of the invention about measuring time, and this I did that I might gain somewhat of belief in those noble persons with whom I was to treat."

It appears that the treaty for a patent would have been carried into effect but for the following stipulation:—"That after I had disclosed the particulars of my inventions about finding the longitude by watches or otherwise—though in themselves sufficient—if they or any person should find a way of improving my principles, he or they should have the benefit of it, during the term of the patent, and not myself, to which clause I could in no way agree, knowing it was very easy to vary my principle a hundred ways, and it was not improbable but there might be some addition of conveniency to discover, it being *facile inventis addere*, and judging it most unreasonable to be deprived of the benefit of my inventions, in themselves sufficient, because others might vary them, or in any other way improve them, of which it is very probable they would not have thought if they had not had the advantage of being instructed by my discovery, it having lain hid for some thousands of years already."

In another of his lectures, No. 3, page 29, Dr. Hooke says: "At the earnest desire of a friend of mine, since dead (Dr. Derham), I did in the year 1664 read several of my Cutlerian lectures upon that subject in the open hall at Gresham College, at which were present, besides a great number of the Royal Society, many strangers unknown to me.

"I there showed the ground and reason of the application of springs to the balance of a watch for regulating its motion, and explained briefly the nature and principle of springs to show the physical and geometrical ground of them. And I explained above twenty several ways by which a spring might be applied to do the same thing, and how the vibrations might be so regulated as to make their duration all equal, or the greater quicker than the less, and that in any proportion assigned. All these particulars were at several other times (at the public meetings of the Royal Society) discussed, experimented upon, and several models produced."

Through the unwise and unjust clause that was proposed to be introduced into the patent the public lost the advantage of the valuable services of Dr. Hooke for a great length of time. It was upwards of fifteen years before he revealed them in print, and then without getting a penny for them, or even a tombstone placed over his grave, which is sometimes given to a man of great talent when dead, although when living he is always allowed to want bread. He was buried in the ancient church of Great St. Helen's, Bishopsgate street, March 2, 1702.

PRACTICAL DETAILS FOR MAKING CHRONOMETER BALANCE SPRINGS.

The first point of importance for consideration is the selection of the material. (I have had a reel of wire unsound all through.)

Secondly, that of taking very great care not to injure it by over-heating in the process of hardening, or by unnecessary bending or straining of any kind.

As steel is more or less injured by the crushing process of the flatting mill, I see no reason why round wire should not be used in preference to flattened wire, and if drawn through ruby holes would be very perfect. However perfect the rollers of a flatting mill may be, I never met with any that did not produce a want of uniformity in the thickness of the wire at every few inches.

It is for the want of uniformity of thickness and strength that two springs of the same length and size and shape at the ends do not produce the same results. Unequality in tempering also contributes towards rendering them dissimilar, some portion of the spring being harder than another, consequently at that point stronger, and thus perplexes the most experienced workman to account for such a great difference in the isochronal properties of the two springs, that, to all appearance, are exactly the same.

In the process of manipulation, springs made with round wire would not be attended with so much trouble as those made with flattened wire.

The less polishing that is done to a spring after it is hardened the better, and the greater degree of certainty there is of it being perfectly homogeneous, a material point for consideration; so that in the action of the spring there may not be the slightest strain upon one point more than another. Polishing them with wood and sharp red stuff I consider quite sufficient.

As it is a very common occurrence for springs not to come off the blocks so true as could be desired, I have found very good results from annealing them, not only once, but a second and a third time, by which every part gets firmly set, and they did not accelerate near so much upon their rates.

I wind the wire up on the first block (a cut one), which I prefer being a little smaller than the finishing one, and securing the ends by left-handed screws. I then place it in a thin copper box about three-eighths of an inch in diameter (inside measure) and three-quarters of an inch deep, smearing it with mottled soap that has been rendered soft by heat (not moisture). I then fill it up tightly as possible with very finely powdered wood charcoal.

For springs that have not got to have their ends turned after been tempered, but left perfectly cylindrical and hard, I prefer the use of animal charcoal, made from horse hoof burnt in a small retort. After hardening in animal charcoal they are very difficult to bend and set true. I then make the box and contents hot to a blood-red heat, but very gradually, and allow it to cool very slowly.

Upon becoming cold I clean the spring and block, and place it on the block again; but, previous to the application of the screws, I place upon it a thin copper tube of enamelled thick copper, spring tight, having covered it with soap as before. The soap protects the steel and has a tendency to improve it. After the copper tube is tight on I slacken the screws and then heat it again to a blood-red heat and allow it to cool very slowly; after which I clean it and place it on a block a little larger, smear it with soap, slip on a copper tube spring tight, place it in a copper box three-eighths of an inch in diameter (inside measure) and three-quarters of an inch deep, and fill it up with finely powdered charcoal as tight as possible; then heat it in a charcoal fire very gradually to a bright cherry red, taking great care not to make it hotter, or keep it for an instant longer than necessary.

I then immerse it into a long tin tube or can (with a small tin can nearly the same diameter as the large can, and with a string attached to it for drawing the spring up without having to empty the large can to get at the spring) about three feet deep, containing water that has been boiled and rendered cold by a freezing mixture, which is now easily to be obtained by pounded ice and common salt placed in a common house pail and surrounding the vessel containing the water.

If the spring is to be a blued one I temper it to a purple before I proceed to polish it; but if it is to be left white I reduce it to the proper temper at once—a very light blue, or rather beyond (bordering on to a black).

As there is much diversity of opinion as to which is the best method of tempering, I do not pretend to decide which is best. As silver is a very good conductor of heat I believe that, if the spring is placed in the box in which it is hardened, and surrounded with very fine silver filings, the result will be a very uniform temper. Place a piece of bright steel in the box also, that you may see the color as it proceeds.

After the spring is set true by bending, I most respectfully submit for consideration the expediency of having it further permanently set by the application of heat up to 500° Fahr., or near the bluing point, to make sure of retaining the figure it was adjusted to; for experience shows that springs do not always retain their isochronal properties for many years, and hence the frequent application of new springs to chronometers, which it is easier to get paid for than for making alterations upon the old ones.

To give a permanent set to a spring, I propose that the spring stud and collet should be placed in a stout metal box an inch deep, and three-quarters of an inch wide, and the temperature raised to near the bluing point, placing a piece of bright steel also to watch the color, and then allow it to cool gradually.

To the finishing block there is no necessity for the screws to be screwed tight; in consequence of its being a little larger than the first block, the spring will hold it tight enough. I give the preference to a spirit lamp to blue all steel work with. If it is to be left white after it comes off the finishing block, I prefer taking off the blue with wood and oxide of iron, commonly called sharp red stuff.

There seems to be a very prevalent opinion that springs which are left white are not so liable to rust as when blued. In support of this opinion I can affirm, from my own personal knowledge, that a box chronometer, made by Monsieur Breguet, in the year 1824, with hard white cylindrical springs, at present shows no symptoms of rust, or did not a few months since.

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Reminiscences of an Apprentice.

FINDING THE LENGTH OF A PENDULUM.

There was no clock inside of our church for a considerable time after it was built, its economical founders considering that the striking of the large clock on the tower would give sufficient warning of the flight of time to the minister and the congregation. A period arrived, however, when the young people of the church thought it would be nice to have a clock inside the church, and a movement was originated among them for the purpose of procuring one, when a native of our town, who was residing in a distant city, hearing of the movement, presented the church with a clock, and sent it to "Our Maister" to fit up. It was a fine spring clock, with a large white dial, and was intended to be placed on the front of the gallery. It was wound up from behind, and the hands could also be set from behind by means of a small dial and pointer placed at the back of the clock frame for that purpose. When the clock arrived we could find no pendulum for it. We searched the packing case and among the loose packing several times, but no pendulum could be found. On communicating this fact to the donor of the clock, we learned that it had been purchased from a jeweller who did not make clocks, but only sold them; and since the pendulum was lost, it was thought that the best thing that could be done would be for "Our Maister" to make a new one.

At the period of which I write I was just beginning to think seriously about some of the strange things I saw around me in the shop, and there was one thought occurred to me in connection with this lost pendulum—how was the "Maister," or any one else, going to find out the right length to make the new one? The clock had no case, and there was nothing whatever about its appearance that gave any indication of what length the new pendulum required to be, and I could see no way to get out of the difficulty except to make the pendulum long enough in the first instance and keep cutting it off till the clock kept the right time. When I communicated my thoughts to "Our journeyman" on this subject he told me that I ought not to be so inquisitive; that if I would wait a little I would see how *they* would find the length of the lost pendulum. He also told me that if the "Maister" did not understand it himself that *he* had learned the secret when he was in London, and advised me not to trouble myself anything more about it, as it was a subject far beyond my comprehension; that it was only intelligent people who had been in London that could understand these things, you know. This rebuff had the same effect on me that rebuffs of a similar nature have on people who are very anxious to find out anything—it only made me the more eager to find out by what means the

length of the new pendulum was to be determined.

In a day or two the clock was taken to pieces, and "Our Maister" took some of the wheels to his bench and silently counted the number of teeth that were in them, and then he gave them to me and told me to count them also. I counted eighty-four in the centre wheel, eighty in the third, and thirty-two in the scape wheel, and eight leaves in the third and scape-wheel pinions, which was exactly the same as the "Maister" had counted. He then made a great many figures on a piece of paper, looked them over to see if they were correct, and then quietly remarked that the new pendulum would require to be about $11\frac{1}{4}$ inches long. In the afternoon the "Maister" was out and "Our journeyman" and I were left alone, and the new pendulum was the subject of conversation. And here I must digress a little and state that we generally used these breathing spells in talking about the "Maister," and criticising his actions and his notions of things in general. If any person had chanced to have overheard our conversations on these occasions and believed all that we said, they could not have helped thinking that "Our journeyman" and I were two of the wisest young people that ever lived, while the "Maister" was the biggest fool in the whole country. "Look!" says I, handing "Our journeyman" the piece of paper the "Maister" had been figuring on; "Look! he uses decimals!" Now, I had a kind of contempt for decimals, because they were so easy; it was the vulgar fractions that puzzled me so much at school; and when I saw he took this easy method I had no great respect for his learning. "Oh, look!" says "Our journeyman," "he told us the pendulum would require to be $11\frac{1}{4}$ inches long, and the figures are 11.250, and he calls that $11\frac{1}{4}$;" and we both joined in a hearty laugh at the "Maister" for what we considered to be his guessing at the length of the new pendulum. "Let him alone," says "Our journeyman," "and let him make it that length. I know he will have to make it over again, and ask me the way. Give me a piece of chalk and I will tell you how long the pendulum ought to be." I handed him the chalk, and after he had covered my bench with figures, he stroked his chin with his finger and thumb and pronounced that, in the latitude of London, the clock would require to have a pendulum exactly 7 feet and $3\frac{27}{29}$ inches long. Now, although I did not know anything about it, I suspected that there must be something wrong somewhere, because a pendulum of that length would project a long way through the lower edge of the church gallery; however, "Our journeyman" maintained that the figures were correct, and while we were earnestly engaged going over them a second time to make sure, the "Maister" came in. "Well, boys," says he, "what is this you are about now?" "Our journeyman" went to his bench without saying anything, and I was obliged to tell him that we were finding the length of the lost pendulum. "And what length have you made it?" he asked good-naturedly. "Seven feet $3\frac{27}{29}$ inches," says I; "there are the figures on the bench." "Seven feet!" he exclaimed; "why, I have only made it $11\frac{1}{4}$ inches." "Well," says "Our journeyman," with an air of great wisdom, "it is the latitude of London I have calculated it for." For about a minute or so the "Maister" looked quite bewildered, and when he recovered he took a bundle of rags and rubbed out all the figures that were on the bench and said, "boys, mind your work."

In about a week after this the new pendulum was completed according to the "Maister's" measurement, and when it was tried on the clock it proved to be exactly the length that was required, and I felt more anxious than ever to learn how the "Maister" could calculate it so correctly, and thought that I would ask him to tell me the way he did it, and was gratified to find that, instead of making any objections to telling me, he felt pleased to see me manifesting so much interest in such matters, and promised to tell me every thing that I wanted to know when he got time. That same afternoon he called me to his bench and asked me to take a stool and sit down by his side. He then took a sheet of paper and a pencil and commenced the first lesson in unfolding the mysteries connected with finding the length of the pendulum. "Let us begin with the centre wheel," says he; "it carries the minute-hand and makes one revolution in an hour. Now, we must first find out how many revolutions the scape-wheel makes in an hour, also. There are 84 teeth in

the centre wheel, and 80 in the third. The centre wheel acts on the third-wheel pinion, and the third wheel acts on the scape-wheel pinion, and both pinions have 8 leaves. Now, if we multiply the number of teeth that are in these two wheels together, and multiply the number of leaves that are in the two pinions together, and divide the one number by the other, it will give us the number of revolutions the scape-wheel makes in an hour. For example:

```
 8        84
 8        80
--        --
64     64)6720(105 times the scape-wheel turns
          64         in an hour.
          --
          320
          320
          ---
            0
```

We must next find out how many beats the desired pendulum will be required to make in an hour. We now know that the scape-wheel turns 105 times in an hour, and that there are 32 teeth in the scape-wheel. Now, it takes two beats of the pendulum to allow one tooth of the scape-wheel to pass. Twice 32 is 64. Multiply 105 by 64, which gives 6,720—the number of beats the pendulum must make in an hour to suit the numbers that are in the wheels of this clock. 6,720, divided by the number of minutes that are in an hour, gives 112, which is the number of beats the pendulum must make in a minute. Now, says the "Maister," we have got so far as to know how many beats our pendulum must make in a minute, and we have to find out next how long it will require to be in order to make exactly this number of beats in that time. We know, by experience, that a pendulum that beats 60 times in a minute is 39.2 inches long, and on that basis we will calculate how long one ought to be that will beat 112 times in a minute. The first step in order to accomplish this result is to square the number of beats the standard pendulum makes in a minute, which is multiplying it by itself; and then we multiply that number by the length of the seconds pendulum, and it will give us the number 1,411,200. We then divide this last number by the square of the number of vibrations the new pendulum will be required to make in a minute, and the product will give the length of the pendulum in inches and decimal parts of an inch.

```
  112 the number of beats the new pendulum has
  112       to make in a minute.
  ---
  224
 112
112
-----
12544

                60   the number of beats the stand-
                60      ard pendulum makes in a
               ----     minute.
              3600
                39.2 the length of the standard
              -----      pendulum.
                7200
               32400
              10800
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I said to myself, this may be all very simple for people who understand it; but so far, I knew just about as much about finding the length of a pendulum as I did before he commenced to tell me. It was true enough what "Our journeyman" said, this was a subject far beyond my comprehension. Why is it, I thought, that so many numbers require to be squared, and why is it that a pendulum 39.2 long beats 60 times in a minute, and one 11¼ inches beats only 112 times; and what has the latitude of London to do with a pendulum? I saw that the result of the calculation was 11¼ inches, but I did not understand anything of the foundation of the rules by which the result was reached, and asked the "Maister" to tell me; but it was evident that the good man was not expecting to have such questions put to him, for he told me he had no more time to spend, just then, but on some future occasion he would tell me all about it, which information will be given in a future number of the Journal.

☞ We hope our readers will send us for publication during the present or following month the result of their experiments for determining the difference in temperature of opposite ends of a pendulum, from which we hope to gather some valuable statistics on this subject.

Spectrum Analysis.

We very much regret that our limited space prevents giving Professor Tyndall's lectures on Light recently delivered at the Cooper Institute. The following is a synopsis of the closing lecture on Spectrum Analysis, as reported in the *World.*

In these lectures the source of light which has been employed are the ends of two rods of coke, made incandescent by the electric current, because coke is especially suited to this purpose by reason of its capacity of enduring intense heat without being fused or vaporized, and also because it is black, since Balfour Stewart has shown that, other things being equal, the blacker the substance the brighter is its light when it is incandescent. Yet, refractory as carbon is, it will be found, on examining the voltaic arc or stream of light between the incandescent points, that the vapor of carbon is present, and its spectrum might be obtained by detaching its light from the more dazzling light of the solid points, and this spectrum would be not only less brilliant than, but of a totally different character from, the spectra already seen. There would not be an unbroken succession of colors from red to violet, but only a few bands of color separated from each other by dark bands. This is still more strikingly true in the case of the spectra of metals, the most refractory of which may be fused, boiled, and reduced to vapor by the electric current. As a general rule, the light from the incandescent vapors flashes in groups of rays of definite degrees of refrangibility, while spaces exist between the groups which are unfilled by rays of any kind. In illustration of this, within the camera is placed a cylinder of carbon, hollowed out like a cup at the top to receive a bit of the metal thallium, and the arc of the incandescent metal appears on the wall as a beautiful green. In order to find the meaning of this green, the light must be subjected to prismatic analysis, and then its spectrum is seen to consist of a single refracted band; light of one degree of refrangibility, and corresponding to green, is emitted by the thallium vapor. If silver be substituted for thallium, its arc will not be distinguishable from that of the other metal, being not only green but of the same shade of green. Prismatic analysis will, however, show that it is impossible to confound the two spectra, for there are two bands of green shown on the wall. If thallium now be added with silver the light of both metals appears, that of the thallium lying between the two of the silver. But another fact must be noticed—now the thallium band is brighter than that of the silver, and in fact the latter has greatly degenerated, the reason of which is that the resistance offered to the passage of the electric current between the carbon points calls forth the heat-producing power of the current. As the resistance is lessened the heat is lessened, and if all resistance were abolished there would be no heat. Thallium is much more readily fused and vaporized than silver, and so greatly does its vapor facilitate the passage of the current as to make it almost incompetent to vaporize silver. As the thallium is gradually consumed, and its vapor diminishes, the resistance rises until the silver bands are as bright as at first, and the three bands become of the same brilliancy. In these bands are a perfectly unalterable characteristic of the two metals: from the silver never come but these two bands; from the thallium never comes but this one, and from a mixture of the two never but these three bands. Every known metal has its characteristic bands or band, and in no known case are those of two metals alike; hence the spectra may be used as a test of the presence or absence of any particular metal. Whenever a certain spectrum appears, the metal of which it is characteristic must be present. In alloys of metal there is no confusion of spectra. Copper, as its spectrum is cast on the wall, gives, as is seen, green bands; zinc gives blue; brass, which is an alloy of these two metals, gives the bands of both perfectly unaltered in position and character. The salts of metals give the metal bands, chemical union being ruptured by intense heat, and the vapor of the metal, being set free, yields its characteristic bands. The chlorides of metals are particularly suited for these experiments. Take common salt, which is the chloride of sodium, and in the electric lamp it yields the bright yellow band of the metal sodium, as you see it on the screen. Bunsen and Kirchhoff examined the spectra of all known substances, and, in doing so, found bands which were those of no known substance, hence they inferred the existence of a new metal.

They were at the time experimenting with a residue obtained by evaporating one of the mineral waters of Germany. They knew the new metal was concealed in the water, and, at last, by evaporating great quantities of the water, they found the metal now called rubidium; afterwards they discovered another called coesium, and this demonstrated the value of spectrum analysis as a means of discovery. Mr. Crooke afterwards detected in the same way the metal thallium yielding this beautiful monochromatic green band. Kirchhoff then turned his attention from terrestrial substances to the investigation of the constituents of the sun and stars, and while thus engaged solved a problem which had long puzzled scientists. The spectrum of the sun is not pure, but crossed by innumerable dark lines, which were first noticed by Dr. Wollaston, but afterwards measured and multiplied so greatly by Fraunhofer that they received his name. To explain these lines was the puzzle. Kirchhoff had made thoroughly clear to his mind the principles which linked together the emission of light and the absorption of light; he had proved their inseparability for each particular kind of light and heat. He had proved for every specific ray of the spectrum, the doctrine that the body emitting a ray absorbed with special energy a ray of the same refrangibility. Consider, then, the effect of such knowledge upon a mind prepared like that of Kirchhoff. We have seen the incandescent vapors of metals emitting definite groups of rays; according to Kirchhoff's principle those vapors if crossed by solar light ought to absorb rays of the same refrangibility as those which they emit. He proved this to be the case; he was able by the interposition of a vapor to cut out of the solar spectrum the band corresponding in color to that vapor. Now, the sun possesses a photosphere, or vaporous envelope doubtless mixed with violent agitated clouds, and Kirchhoff saw that the powerful rays coming from the solid or the molten nucleus of the sun must be intercepted by this vapor. One dark band of Fraunhofer, for example, occurs in the yellow of the spectrum. Sodium vapor is demonstrably competent to produce that dark band; hence Kirchhoff inferred the existence of sodium vapor in the atmosphere of the sun. In the case of metals which emit a large number of bands, the absolute coincidence of every bright band of the metal with a dark Fraunhofer line raises to the highest degree of certainty the inference that the metal is present in the atmosphere of the sun. In this way solar chemistry was founded on spectrum analysis. To illustrate the meaning of emission and absorption the Professor made use of two tuning forks capable of similar rates of vibration. When one was caused to vibrate by a bow drawn athwart it, the other vibrated synchronously, but when, by placing a cent piece on each prong of one of the forks, its perfect synchronism with the other was destroyed, no communication of sound from one to the other was possible. By placing a little sodium in a Bunsen flame, something analogous to what had been done with waves of sound was done with waves of light. An intensely yellow light was made in the flame corresponding with the yellow band in the spectrum. The light of the lamp was then sent through the flame to prove that the yellow flame intercepts the yellow of the spectrum, and produces a dark Fraunhofer's band in the place of the yellow. Every age of the world is the offspring of all preceding ages. Science proves itself to be a genuine product of nature by growing according to this law. We have no solution of continuity here. Every great discovery has been duly prepared for in two ways: first, by other discoveries which form its prelude; and secondly, through the sharpening by exercise of the intellectual instrument itself. Thus Ptolemy grew out of Hipparchus, Copernicus out of both, Kepler out of all three, and Newton out of all the four. Newton did not rise suddenly from the sea-level of the intellect to his amazing elevation. At the time that he appeared the table-land of knowledge was already high. He juts above the table-land as a massive peak; still he is supported by it, and a great part of his absolute height was the height of humanity in his time. It is thus with the discovery of Kirchhoff. Much had been previously accomplished; this he mastered, and by the force of individual genius went beyond it. He replaced uncertainty by certainty, vagueness by definiteness, confusion by order; and I do not think, said the lecturer, "that Newton has a surer claim to the discoveries that have made his name immortal than Kirchhoff has to the credit of gathering up the fragmentary knowledge of his time, of vastly extending it, and

of infusing into it the life of great principles. Splendid results have since been obtained in relation to which both England and America have played an honorable part; but they are but the sequel and application of the principles established in his Heidelberg laboratory by the German investigator." Up to his demonstration of the composition of white light, Newton had been everywhere triumphant—triumphant in the heavens, triumphant on the earth—and his subsequent experimental work is for the most part of immortal value. But he made some errors, and finally his theory gave way to the undulatory theory. I have now come almost to the end of my task in this city, and, indeed, in America. My desire has been to show you, with as little breach of continuity as possible, the past growth and present aspect of a department of science in which have labored some of the greatest intellects the world has ever seen. I have endeavored in these lectures to illustrate before you the power of the undulatory theory as a solver of all the difficulties of optics. Do I therefore wish you to close your eyes against any evidence that may arise against it? By no means. The theory of undulation, like many another truth, had to establish, by hot conflict, its right to existence. Yet at last it triumphed. And now my occupation is gone. Still I will bespeak your tolerance for a few concluding remarks in reference to the men who have bequeathed to us the vast body of knowledge of which I have sought to give you some faint idea in these lectures. It is never to be forgotten that not one of those great investigators had any practical end in view, according to the ordinary definition of the word "practical." They did not propose to themselves money as an end, and knowledge as a means of obtaining it. For the most part they nobly reversed this process, and made knowledge their end. Could we have seen these men at work without any knowledge of the consequences of their work, what should we have thought of them? Could you watch the true investigator in his laboratory, unless animated by his spirit, you could hardly understand what keeps him there. Many of the objects which rivet his attention might appear to you utterly trivial; and if you were to step forward and ask him what is the use of his work, the chances are that you would confound him. That scientific discovery may put not only dollars into the pockets of individuals, but millions into the exchequers of nations, the history of science amply proves; but the hope of its doing so is not the motive power of the investigator. With reference to material needs and joys, pure science has also a word to say. You are delighted, and with good reason, with your electric telegraphs, your steam-engines and your factories, and the productions of photography. You see daily, with just elation, the creation of new forms of industry—new powers of adding to the wealth and comfort of society. Industrial England is heaving with forces tending to this end, and the pulse of industry beats still stronger in the United States. And yet, when analyzed, what are industrial America and industrial England? At the present time there is a cry in England for technical education, but there is no outcry for original investigation. Still, without this, as surely as the stream dwindles when the spring dries, so surely will their technical education lose all force of growth—all power of reproduction. To keep society as regards science in healthy play, three classes of workers are necessary: First, the investigator of natural truth; secondly, the teacher of natural truth; thirdly, the applier of natural truth. These three classes ought to coexist, and interact upon each other. Now, the popular notion of science, both in this country and in England, often relates, not to science strictly so called, but to the applications of science. Such applications, especially on this continent, are so astounding as to shut out from view those workers who are engaged in the profounder business of discovery. Different qualities of mind and different habits of thought are the necessary supplements of each other; but remember that one class is sure to be taken care of. All the material rewards of society are already within their reach; but it is at our peril that we neglect to provide opportunity for those studies and pursuits which have no such rewards, and from which, therefore, the rising genius of the country is incessantly tempted away. It is not as lecturers, but as discoverers, that you ought to employ your highest men. Give them the freedom necessary for their researches, not overloading them with either the duties of tuition or of administration. Let them make truth their object, however impractical for the time being that truth may appear.

"Clyde" on the Friction Question—Additional Remarks.

For some time I have been contemplating making another communication on the friction controversy, but the pressure of other business has prevented me from putting my intention into practice till now.

In the September number of the JOURNAL your correspondent, B. F. H., accuses me of not understanding his experiment with the Swiss lathe, which he describes so plainly on page 261, third volume. Now, any one who can read cannot fail to understand that experiment, and what its author was trying to prove. There is nothing mysterious about it. All I wanted to show, in talking about it, was that we had no proof that the mandrel of the lathe was absolutely true, and that the character of the polish was the same on every part of its surface. It made no difference whether the polish was coarse or fine; all that was necessary was, that it should be the same all over, and that the bearing surfaces should be of the same degree of smoothness all over, and fit with equal tightness against the steel in whatever position the steel was turned. Unless all these conditions were complied with to the letter, the experiment is worthless. The very fact of using a different kind of metal for one of the bearings, although it may have been more convenient, is of itself ample proof of how widely different the experimenter and I regard the principles which underlie the question.

Your correspondent still seems to have unlimited faith in Parker's Philosophy as an authority on the subject of friction, and argues that, as Parker, in the preface to his book, admits his obligations to nearly every work which has been referred to on both sides of this discussion, he, as a consequence, must have taken the cream from the whole when he states "that friction increases as the extent of the surfaces in contact is increased." This is certainly a very clever argument, and apparently it is a sound one; yet it is as fallacious as it is ingenious. In the first place, out of more than fifty authorities Parker quotes, only four of them have been quoted by any one during the progress of this discussion. I have a copy of Parker's Philosophy in my possession. It is a school-book which treats on all the various branches of physics, but it must not be understood that the authorities which Parker quotes are quoted to support his statements on the subject of friction alone, but they are the foundation on which the general subjects treated in his book are based upon. I have looked up all the works he quotes that I can find, and there is none of them supports the literal statements he makes in regard to friction. Parker states that friction increases "as the extent of surfaces in contact is increased," and that it may be diminished "by lessening the amount of homogeneous bodies in contact with each other;" but he does not state that these results are obtained *when the surfaces are clean and of the same quality, or when they are equally smooth or equally rough.* This is the point the whole of our argument hinges upon; and there is no man who undertakes to write or compile a book on the subject of friction, and demonstrates the statements he advances, could make any such assertion, because the reverse has been proved, over and over again, by actual experiment; and I have no hesitation in saying that, on the particular subject of friction, Parker cannot show sufficient authority for all the statements he makes, if we interpret them literally.

This correspondent quotes, on the authority of the *Scientific American*, that Morin's experiments were not satisfactory and that they had not been carried far enough, and he also states that within a year an editorial appeared in that paper which supported that opinion. I think that I remember the article which he refers to. If it be the one I think it is, it was one of a series that was contributed by a mechanical engineer in one of the Northwestern States on the application of frictional gearing for saw-mills, and was published about nine months ago. I understood his statements to refer to an entirely different branch of the subject than the one we are discussing. I do not assert that Morin's experiments were carried far enough, any more than I would assert that the limit has been reached in any branch of practical science; but I will maintain that Morin demonstrated by practical experiment that the sliding friction of certain bodies was entirely independent of the extent of the surfaces in contact when they were clean and of the same quality, and when the pressure was not great enough to abrade

them. To show how the *Scientific American* regards Morin as an authority on this subject, I make a quotation from an answer to a correspondent which appeared in a recent number. On the second column of page 408, they say that "Morin's experiments are generally considered standard and perfectly reliable. The only difficulty in applying known laws of friction to actual examples arises from the uncertainty of our determination of the limits of pressure which may injure or change the character of the rubbing surfaces."

In order to have something really practical, I am requested to describe the model in the Cooper Institute, which illustrates the effects of friction on long and short pivots, and on their ends. I find that in my last communication I made a premature statement with regard to the models in the Cooper Institute. Professor Plympton, who is in charge of the school of Natural Philosophy in that Institution, informed me that negotiations were in progress with a party in Boston for obtaining a set of such apparatus as would be required for this purpose. Two sets were to be made at the same time: One for the Institute of Technology, in Boston, and the other for the Cooper Institute, in New York; but so far none of the models are ready. I was informed by Professor Thurston, while on a visit to the Stevens Institute, at Hoboken, that he had also ordered a set of such mechanical models; I think he said from Europe. One model of special construction he is having made here, designed to test the value of different qualities of oil on pivots; and when it is completed I hope to see a description of it in these pages, and also some of the results obtained from it. Professor Thurston informed me that there was no doubt at all about the fact that the friction of a pivot working in a hole was of the same nature and subject to the same laws as one flat surface sliding over another. The fact of the existence of such models as are necessary to illustrate the statements I have made on this question, is beyond all dispute. I have seen them myself in Europe, and Mr. Shroeder, of the firm of Jas. Queen, optician and instrument maker of Philadelphia and New York, is agent for his father, who makes such models in Germany.

Some time ago I determined to make an apparatus to practically demonstrate the effects of friction on long and short pivots. I could not trust myself to make an axis perfect enough in a lathe by hand, and hearing that there was a machine in the United States Watch Factory that could do the work as I desired it to be done, I applied to Mr. Hart, the superintendent of the factory, to get such an axis as I required made. Mr. Hart very generously offered me all the assistance that was at his command, but as yet I have not received the axis. While waiting, I resolved to try the experiment of sliding one flat surface over another. For this purpose I selected a piece of plate glass, about twelve inches long and about six inches broad, and took the base of one of Bissell's staking tools as being the most convenient material for the purpose that was at my disposal at the time. This staking tool must be familiar to many readers of the Journal, but for the benefit of those who may have not seen one, I will mention that the base of one of these tools is a piece of gun-metal, about four inches long and about one and a half inches broad, and is nearly square, and, without the steel, weighs about two pounds. A piece of steel that contains the holes is dovetailed into one side of this gun-metal. I removed this piece of steel, which left two edges of gun-metal sufficiently broad to bear the pressure of the weight without in any way injuring the surfaces. I then took the lacquer off one of the other sides and ground it as flat as I could, and also ground the side where the steel had been taken out, till all the surfaces that were intended to be rubbing surfaces were as near the same degree of smoothness as possible, and washed them thoroughly clean. I then placed a small pivoting lathe in the vise, putting a pulley, fastened on an axis, between the centres. I then took the piece of plate glass and placed it in a convenient position on the bench opposite to the pulley in the lathe, and finally attached a piece of stout thread to the gun-metal, and placed the gun-metal on the glass and passed the thread over the pulley and suspended a weight on to the end of it.

During the progress of my preparations, several mechanics, who knew what my design was, ridiculed the possibility of obtaining the results I anticipated. They were men, too, whose opinion on many subjects was worthy of consideration, but they had never studied the laws

of friction. It was the same old story with them as has been with a great many others whose attention has been directed to this subject for the first time. I was endeavoring to turn the laws of nature upside down; was aiming at results against all common sense; that the pressure of the atmosphere, the effects of cohesion and adhesion, rendered the results I anticipated impossible, and innumerable examples were brought forward to show the fallacy of my assertions, although I was making no assertions but what had been proved by actual experiment, over and over again, and by different people in different parts of the world. When my preparations were completed, the result of the experiment was eagerly watched by the spectators; and when they saw that it took precisely the same amount of weight to move the gun-metal over the glass when a bearing surface of about 10 square inches was in contact with the glass as it did when a bearing surface of only 3 square inches was in contact, the tone of their remarks was changed, and they admitted that, after all, there must be something about the laws of friction that they had never studied. Previous to the experiment, one gentleman made himself very conspicuous in his opposition to the idea that friction is independent of the extent of the surfaces in contact, and he offered five dollars to any one who would prove it to him. I invited him to see my experiment. He thought the results were very wonderful. I told him that it was nothing wonderful at all; that, before motion could be produced, the gun-metal had to be raised a sufficient height to allow the asperities on its surface to pass the asperities on the surface of the glass, and that, under certain conditions, it was as easy to raise the gun-metal when it rested on its broadest surface as it was when it rested on its narrow one. He expressed himself pleased with the manner in which the experiment was conducted, but neglected to say anything about the five dollars.

I am requested by B. F. H. to analyze Ried's statement, "that the balance will vibrate twice as long in one position as the other; that in his opinion they could be made to vibrate the same in either position; and that, also, in his opinion Ernshaw's shallow holes and flat pivot ends should come very near that object." The above statements are to be found on page 233 of Ried's Treatise; but one important part of Ried's statement has been omitted. This is what he says: "We are humbly of opinion that the balance, with its spring in an isolated state, could be made to vibrate the same length of time in both positions. *But who will be at the trouble and expense to make such experiments as may lead to this?*" Since Ried's day these experiments have been made, and I would have thought that at this stage of our discussion there would have been no necessity for referring to this particular branch of it. We all know that when the pivots of a balance rest on their rounded end the balance will vibrate a longer time than when they rest on their side; but what is the reason of this? Is it because the bearing surfaces are larger in the one position than in the other? No, nothing of the kind. The reason has been demonstrated over and over again in this discussion, that it is owing to the fact that the resistance to motion is farther from the centre of motion in the one case than in the other. Flatten the ends of the pivots and you distribute part of the resistance farther from the centre of motion and more in equality with the resistance on the sides of the pivots. Hollow out the ends of the pivots, and although there be less surface in contact than when they are perfectly flat, the resistance to motion will be greater and nearer an equality with that of the sides of the pivots than can be produced by any other method. To show what Ried thought of large bearing surfaces in some instances, I will make another quotation from page 212 of his work: "Mr. Smeaton, at this period, took away gudgeons from a mill-wheel, whose diameters were only two and half inches, and put others in their place of eight inches, with great success, as it afterwards proved."

I would beg leave to direct a little attention to two experiments, described on page 115, third volume of the JOURNAL, and I am a little surprised that some correspondent has not noticed the results shown by these two experiments. The first one is with a watch. It does not say in the description of the experiment, what kind of a watch it was, but I have learned that it was a detached lever. In this watch the balance pivots were slightly reduced at the ends next to the shoulder, with the view of making the rubbing surfaces on the jewel holes

smaller. This alteration had the effect of increasing the vibration of the balance, and the increase in the vibration altered the rate of the watch. The ends of the pivots were also flattened, but I will omit that part of the experiment because it has no connection with the object I have at present in view. It is enough that the reduction of the rubbing surfaces of the sides of the pivots had the effect of increasing the vibration of the balance and altering the rate of the watch. The other experiment was with a duplex clock, and the same operation had the effect of increasing the arc of vibration of the balance as much as 20 degrees; but this extra increase in the vibration did not alter the rate of the clock as it did in the case of the watch.

Now this looks to me as being a very remarkable result. In the lever watch we have the balance entirely independent of the train, except at the instant the roller is in action with the fork. In the duplex escapement the whole pressure of the train is acting against the balance staff nearly the whole of the time, and consequently there is more friction on the pivots, as well as the additional friction of the scape-wheel teeth, which also affects the balance in the duplex escapement. Yet in the escapement where there is the most friction, an addition of 20 degrees to the arc of vibration of the balance did not alter the rate; while in the detached escapement an increase of the arc of vibration of the balance did alter the rate. Can any one give a reason for this?

In this communication, as well as in the last, my main object has been to show, in a plain way, that in the case of one hard body sliding over another, a pivot sliding round in its hole, or any similar case of sliding friction, a separation of the surfaces in contact has to take place before motion can be produced. I am inclined to think that, in the case of rolling friction, a separation of the surfaces does not take place to the same extent as in sliding friction. In rolling friction the asperities on the surfaces may be supposed to work into each other in the same manner as the teeth of a wheel works into a pinion, or a pinion works into a rack; and the fact of the surfaces in contact not requiring to be separated accounts for the ease with which rolling surfaces work against each other compared with sliding surfaces. The friction in the experiment of B. F. H. with the mandrel of the lathe is of a different nature from any of these. If the brass touched on the steel around its entire circumference, motion could not be produced without compressing some of the asperities, and the difficulty of producing motion would increase in proportion to the truth of the axis, the number of asperities in contact, the amount of force with which they pressed against each other, and the elasticity of the metals employed. As a general rule in sliding friction, the proposition "Dynamics" made at the beginning of this controversy, "that within moderate limits friction is caused by pressure, and not by the extent of the surfaces in contact," will be found to hold good in almost every instance; yet, like every general rule, there are exceptions. Dr. A. Baumgartener, Professor of Physics in the University of Vienna, states that the friction of surfaces covered with wool are not independent of the extent of the surfaces in contact; and I have the authority of Professor Rankine, of the Glasgow University, who is probably the greatest living authority on the subject of steam engineering for maritime purposes, that the friction of iron rubbing against iron is not entirely independent of the extent of the surfaces in contact. Mr. Hagey's remarks on the electrical arrangement of the atoms in the last number is a very feasible one in the case of the iron surfaces, and no doubt the attraction of cohesion exerts its influence in proportion to the affinity the particles of the metals employed have for each other. It is possible to file or to grind two pieces of metal so accurate, that, when they are placed together, they will adhere to each other with a force greater than the attraction of gravitation can overcome. The same result can be obtained with moderately small surfaces as well as with larger ones, and the difficulties arising from the attraction of cohesion in sliding one surface over another is as easily, or almost as easily overcome in the one instance as in the other; and in instances where the particles of metal have little affinity for each other the attraction of cohesion is not perceptibly felt. I now claim that, as a general rule, "Dynamics' " proposition has been proven by an overwhelming mass of evidence. From that standpoint we can easily explain the effects we see produced by metals of various natures rubbing against each

other, the influence of oil, dirt, etc., and the inequalities of the mechanical imperfections of the rubbing surfaces; and we also can understand why, in some instances, narrow surfaces have more friction than broad ones, as was exemplified in the case of Mr. Gribi's first brick experiment, and which we see illustrated in common life every day.

"Horologist," feeling the weight of the testimony that was against him, acknowledges his error. B. F. H. has shown himself to be an earnest and able advocate of what he considers to be right, and there are few who could make such an able and formidable attack upon so strong a position as the one he assails; but I would now mildly suggest to him and to Mr. Hagey, and to all others who may be wavering, the propriety of following Horologist's footsteps and come over to our side, because it is the only position in which the weary who are seeking to unravel the mysteries of friction can find rest.

We have lately been favored with several communications from Mr. Muma, embracing both physics and metaphysics. Mr. Muma thinks "that the laws of nature cannot always be followed with advantage." Does Mr. Muma really mean this, or is it a slip of the pen? I am inclined to think that he must mean it, because on page 117 he has also been telling us of a watch pocket that sometimes gets ahead of nature. For myself I do not aim so high.

"Thou, nature, art my goddess;
To thy laws I bow."

CLYDE.

Church Clocks.

ED. HOROLOGICAL JOURNAL:

Noticing that the HOROLOGICAL JOURNAL is occupied mainly with matter pertaining to watches, and that clocks, especially large ones, are somewhat neglected, I have taken the liberty of asking you to find room for the following account of probably the largest clock factory in Great Britain—the largest certainly so far as variety of products goes—ranging from small clocks for domestic use, to the largest and most elaborate cathedral clocks. And here let me ask—have we a church clock among us? one really reliable and fit to regulate even an old-fashioned "bull's eye" by? There are plenty where the brass work shines with unearthly lustre, but in the two cities not one, so far as I know, with either a train remontoir or a gravity escapement. "*The old and well-tried dead beat*," with a short pendulum, swinging about fourteen inches each side of zero, seems to rule; and one accustomed to these things can give, without having seen it, an exact description of any given clock in any public building in New York or Brooklyn. I have often wondered if the old clock on our venerable New York Post Office were not, with the exception of a less liberal supply of hands, a duplicate of the one on the City Hall. By the way, cannot some one of your contributors give us information relative to the former clock? Frequently when passing, I have been tempted to scale the worm-eaten stairs which must lead to the tower, but the ferocious officials, the "Positively no Admittance," and a vague fear of the awful Postmaster who is supposed to inhabit the inner recesses of the building, have terrified me, being naturally of a timid and nervous temperament, and prevented the accomplishment of the plan.

The firm of Gillett & Bland have long enjoyed a reputation as makers of church, turret, and house clocks; though so much of their work has been for the trade, their names have not been as widely known as those of some others. Their works at Croydon, England, are sufficiently extensive to admit of performing all the operations incident to the manufacture of clocks, from the largest church clock to the smallest house clock. The establishment comprises an iron foundry, with cupola or blast furnace for melting, and the necessary tools and materials for casting all the frames, wheels and other cast-iron parts of clocks for public and private institutions.

In the brass foundry are three furnaces, of the usual construction, but varying in size, for melting the alloys of copper and tin that are required for wheels, bells, etc. The frequent imperfections of castings obtained from ordinary foundries early forced upon this firm the necessity of making their own castings, and from this circumstance has originated much of the elaborateness of the present works, wherein the proprietors can control with certainty the character and quality of all their materials. Adjoining the foundries is a smith's shop, furnished with forges and tools for making all the necessary

forgings required in the larger clocks. In convenient proximity to the brass and iron foundries is a well furnished pattern shop for making patterns and other necessary wood-work.

Centrally located is the engine room, containing a pair of horizontal high-pressure engines of 20-horse power (nominal), which supply the motive power to the different shops. Here, also, is a patent fan for blowing the blast furnace through some 50 feet of underground pipe, and the smith's forges by suitable branches. The boilers are the ordinary Cornish boilers, detached with their furnaces from the main buildings for greater security from fire.

These various establishments form the preparatory department of the works, after leaving which the rough pieces pass into special departments, according to the nature of the work to be fitted up.

Of these fitting departments the chief in importance is the one where cathedral, church, and turret clocks are manufactured. This is, in fact, a modern machine shop, completely fitted with the most elaborate automatic and other machinery, planing and drilling machines of various sizes, lathes, screw and wheel-cutting machines; indeed every thing needful to construct time-keeping machinery of the largest dimensions. For smaller clocks there is a second department, differing from the first mainly in being supplied with lighter machinery of the same class, and with presses for cutting out wheels from sheet brass. In this department are made the smaller clocks, such as are used on factories, schools, etc.

These departments turn out the component parts of various horological apparatus, but after the separate parts have been individually constructed, comes the important operation of assembling them so as to form the complete machine. The individual parts are then transferred to the finishing shop, where, after having been duly painted or lacquered, they are put together, set in motion, adjusted, and thoroughly tested to insure smoothness and accuracy of going. They are then lowered into the packing shop on the ground floor, boxed up and sent away to various parts of the world.

The house clock shop, as its name imports, is appropriated to the smaller class of clocks for domestic use in hall, kitchen, or living room. A great variety of clocks are here manufactured, both spring and weight, going and striking, and a large number of workmen are engaged at the long benches with which the room is lined in performing the various operations connected with this branch of the business.

In the next department are constructed two very different classes of clocks, occupying almost the antipodes of the horological world. This department is known as the musical clock and astronomical regulator department, and is devoted solely to a class of work requiring the highest degree of mechanical skill and precision. It need hardly be observed that, though its parts are few and their relations simple, yet the construction of an astronomical clock demands not only tools of a superior order, but also talent specially adapted to use these tools. This department therefore embraces all that modern engineering skill can give in the way of instruments, as well as a body of skilled mechanics who have made this branch of Horology the study of years. In this department are two exquisitely constructed wheel-cutting machines; one for small wheels, and one for large ones up to 12 feet diameter. The smoothness and accuracy of the work done by these machines is such that the teeth are never touched with a file after leaving the machine.

A noteworthy musical clock was recently constructed here to fit a case which for 150 years had been in the family of Captain Hans Busk. The hours are struck on a large bell; the quarters are chimed on eight bells; and in addition it can chime the "Cambridge quarters" on four bells, either of them at will by an ingenious mechanical arrangement. The clock will also play seventy different tunes upon sixteen bells, the tune being selected by turning an index upon a dial; also, by means of a stud to be pushed, the same tune may be repeated any number of times. There are ten barrels, each adapted for seven tunes, and easily changed for one another.

Without describing particularly the mechanical details of the church clocks constructed here, it may be mentioned that, in addition to improved arrangements of motive power and train, every first-class clock has a gravity escapement in lieu of the dead beat, and is provided with train remontoir to prevent the inequalities in the train from reaching the escapement. One of Messrs. Gillett & Bland's large

clocks formed a prominent object in the International Exhibition of 1872. This clock showed time on two dials—one within and the other outside the building, and had Dennison's double three-legged gravity escapement, and by means of two life-sized figures, provided with internal wheelwork, struck the hours on a bell of twenty-five hundred weight.

The patent Carillon machinery is worthy of notice, as it is an extremely ingenious and effective chiming apparatus. The object is to allow the barrel and moving parts to be made lighter, and to allow the whole to operate with greater certainty and precision. There is also, incidentally, a great reduction in dimensions and weight of material, to say nothing of uniformity of effect and faithful rendering of the melody.

For this purpose the ordinary action is separated into two parts. Usually the pins of the barrel effect, first, the elevation of the hammer, and then its blow.

As arranged by Messrs. G. & B., the work of the pins is confined to releasing a detent, and thereby causing the hammer to strike the bell, its elevation being caused by a separate mechanism.

This apparatus is shown in Fig. 1, where A is the pin barrel, B the cam barrel, C the lever which at one end carries the staple *c*, which connects with the hammer wire, and at the other end has a spring finger E, whose natural impulse is to fly out of the way of the cams on barrel B, but which is thrown in their way by a stop which it strikes as the lever falls. Over

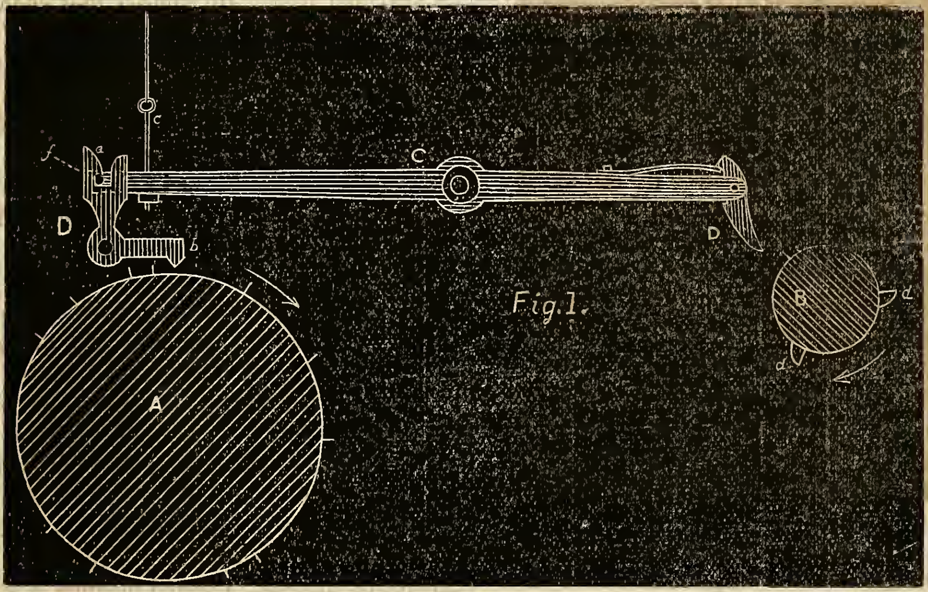

Fig. 1.

the pin barrel A is a detent, in form like a bent lever, which catches on the pin *f* when this end of the lever is depressed, and holds it in position.

The action of this apparatus can be seen at a glance. While the clock is playing, the cam barrel B is revolving continuously, at rather a rapid rate; this, by the cams *d*, raises that end of the lever, when the pin *f*, catching in the notch of the detent D, holds the lever in position, and the hammer elevated until one of the pins in the barrel A, striking the tail of the detent, releases the lever and allows the hammer to fall.

The effectiveness and precision of this mechanism must be seen, to be appreciated. The motive power is obtained by weights, and the speed, as in other clocks, is regulated by revolving vanes, capable of easy and instantaneous adjustment. In short, this automatic musician is perfection of its kind, and, by the addition of a key-board chiming the bells to any tune, improvised or otherwise, is brought within the capacity of any musician, ladies not excepted.

Another recent invention, patented by Mr. Siddons, and made at this establishment, is called a "Chronoscope," and is in fact a clock

showing the time on the principle of a "counter," or engine register. The complete instrument is shown in Fig. 2. As may be seen, it consists of a case made to suit the fancy, and in which the usual circular dial is replaced by an oblong opening through which appear the rims of four wheels, upon which are painted or engraved the requisite figures for indicating the hours and minutes from 0h. 0m., or 0h. 1m. to 11h. 59m. The wheel on the right derives its motion directly from the train, and having completed its revolution and shown all the digits, when moving from 9 to 0, also moves its neighbor on the left, and causes it to indicate 1, and each successive revolution of the right hand wheel adding 1 to the indication of the next

Fig. 2.

wheel until, together, they indicate 59. Their next movement actuates the third wheel and causes it to indicate 1, when the three wheels will stand thus—1–00; and so the movement proceeds until the whole twelve hours are registered. This method of indicating the march of time possesses, for certain purposes, many and obvious advantages over the ordinary dial, especially for children and uneducated persons.

Hoping that this account, which is largely due to a recent article in the *Mechanics' Magazine*, may prove of interest to some of your readers, I submit it.

Brooklyn, N. Y. A. B.

[The Journal has for some time contemplated giving a description of the prominent public clocks of the city. Although there are no remontoir or gravity escapement tower clocks that we know of in New York or Brooklyn, still we hope to be able to convince our correspondent that there are several that could be safely trusted to regulate an ordinary watch by.]

———o———

Compensation Balances and Balance Springs.

Ed. Horological Journal:

In the November number I notice some remarks on the subject of balance springs, giving Mr. Bell's experience and observations on the effects produced by changing the balance springs of watches that had been previously adjusted for heat and cold. He noticed that changing the balance-spring altered the time of the watch, but did not affect the accuracy of the compensation; or, in other words, when the balance was adjusted for one spring the adjustment was equally accurate for another spring, although it might be considerably longer or shorter than the one with which the balance was originally adjusted.

All who have studied the laws which govern the action of a spiral spring, will acquiesce in the accuracy and soundness of Mr. Bell's observations, and agree with him that the effect of a change of temperature in altering the *length* of the spring does not materially interfere with the accuracy of the compensation adjustment, and that the effect of a change of temperature on a short spring is equal in effect to the same change of temperature on a longer one. In support of this idea, I would mention a simple fact, which must have come under the observation of every watchmaker, that in regulating a watch with a long hair-spring, the regulator must be moved a greater distance to have a certain effect on the rate of the watch than when the hair-spring is a short one, which clearly shows that a slight change in the length of a short hair-spring gives equal results to a greater change in the length of a longer one. During the past few years I have heard watchmakers make use of the above facts as an argument to show that a balance was compensated, not for the purpose of counteracting changes of temperature on the spring, but simply to counteract the effects of heat and cold on

the balance itself; but it appears to me that those who incline to this belief leave out of consideration the effects of a change of temperature in the *elasticity* of the spring.

I understand that Mr. Kline, of the United States Watch Factory, has, for a long time, been investigating this subject, and think he must be in possession of facts, the results of experiments and observations, that would be of value in the consideration of the question whether the balance requires to be compensated to counteract the effect of changes of temperature on the balance-spring, or simply to correct its own errors, and I feel sure the readers of the JOURNAL would like to hear from him on this subject. H. J. S.

N. Y. City.

———o———

Answers to Correspondents.

F. G. C., *Boston, Mass.*—The description of the Rounding-up Cones in the December number of the JOURNAL was translated from a pamphlet loaned us by Prof. Egleston, of Columbia College, who has one of the tools in use, and of which, in answer to your query, he writes as follows:

"Mr. Grossmann is the only one I know of who has the rounding-up tools (cones and cylinders), he being the agent for them. I do not know the price. The one I have is not for watches but for clocks, and cost fifteen thalers. It will perfect wheels which are not true in diameter, and, in this sense, Mr. Grossmann stated it worked better than the ordinary rounding-tools, but would take some time to reduce a wheel very much too large, but it is preferable to the ordinary tool in any case. One of the largest watch factories I have seen in Europe has no Swiss rounding-up tool, but depends on the cones; or, when there is a great deal of work of exactly the same kind to do, on cylinders made in the same way. It does not require that the leaves of the cone should be of the same number as the pinion."

S. S. B., *Marion, Ala.*—The column headed "Siderial Time of the Semidiameter passing the Meridian," shows, for each day of the month, the length of time occupied by the passage of one-half of the sun's disc across the meridian, expressed as an interval of siderial time, its use being to determine from an observation of the transit of either limb, or edge, of the sun, the precise instant when the centre of the sun was on the meridian; or, in other words, the instant of apparent noon.

Suppose a transit instrument correctly adjusted in the meridian; the centre line in the field of view then coincides with the meridian. When the sun is passing the meridian, if we could judge with sufficient accuracy the moment when the sun's centre is on the centre line, this column would be of no practical value; but as the eye cannot be depended upon with sufficient certainty for very exact results in this particular, resort is sometimes had to the method of observing the transit of the sun's edge, and then applying the semidiameter as a correction, according as the first or last limb is used; but as the semidiameter, as taken from the *Nautical Almanac*, is expressed in siderial time, if the greatest accuracy is required it must be first converted into mean time by applying a small correction, which may be found in the foot note. For instance, suppose at New York, on January 1st, 1873, we desire to find the error of our chronometer by this method.

	h.	m.	s.
The semidiameter on that day is, 71.07 sec., or what is the same thing		1	11.07
Subtract correction			.19
		1	10.88
Suppose the first edge of the sun is observed to make contact with the centre line, by the chronometer, at	12	3	29.50
Add semidiameter		1	10.88
Apparent noon by chronometer	12	4	40.38
Now the Equation of Time for that date at Greenwich apparent noon is	0	3	59.08
Add, according to the precept, to	12	0	0
	12	3	59.08
At this time of the year the Equation is increasing, and at the rate of 1.182 s. for every hour of longitude; therefore, as New York is 4 h. 56 m. west of Greenwich, we multiply the "diff. for 1 hour," 1 182 s., by the longitude in time, and add		0	5.83
	12	4	4.91

The reasoning now is this: On January 1, 1873, apparent noon really corresponds with 12h. 4m. 4.91s. mean time; or in other words, apparent noon was later than mean noon 4m. 4.91s. According to the chronometer, apparent noon was observed to be 4m. 40.38s. later than mean noon; therefore the chronometer indicated too much time by 35.47s. and was

that number of seconds too fast. Of course, if the transit of the last limb had been observed, the semidiameter would have been subtracted.

We have been minute in this explanation in order again to try and remove some of the mystery that hangs about the subject of your inquiry, and which has prevented the use of the transit instrument among watchmakers, except to a very limited extent, until the introduction of an improved form of this almost indispensable instrument by Messrs. John Bliss & Co., whose advertisement is so familiar to our readers. Not only does their improvement enable any person of ordinary intelligence to accurately adjust their transit in the meridian without knowing the "why and the wherefore." but the above process of applying the equation is simplified by the use of a table of *corrected equation* and instructions which they furnish with each transit. To show the success to be expected in using their transits, we call attention to an additional testimonial which they publish in this number.

D., *Syracuse.*—1*st.* The reason the shell of gold is left as stated, is, because mostly the plated jewelry is rolled plates of more or less thickness; and the base metal that underlies the film of gold is eaten away by the acid, which does not act upon the gold. This is usually so thin as not to sustain its own weight; consequently it breaks up into fragments. 2*d.* You misunderstand the statement on page 118. The alloy mentioned is *not gold;* it is supposed to contain a little gold which is to be recovered, and the dilute nitric acid mentioned is adequate to dissolve the base metals in the compound and leave the gold undissolved in the form of a gray powder. 3*d.* You can only get vol. 1 of the JOURNAL from private hands; we know of but one copy for sale, and that the fortunate possessor values at $25.

[We are obliged to omit several answers for want of space.]

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For February, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be added to Apparent Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	S.	H. M. S.
Saturday......	1	68.22	13 54.37	0.319	20 47 2.36
Sunday	2	68.11	14 1.62	0.284	20 50 58.92
Monday.	3	67.99	14 8.03	0.247	20 54 55.47
Tuesday	4	67.88	14 13.59	0.214	20 58 52.03
Wednesday....	5	67 76	14 18.31	0.180	21 2 48.59
Thursday	6	67.65	14 22.22	0.146	21 6 45.14
Friday........	7	67.54	14 25.30	0.112	21 10 41.70
Saturday......	8	67.43	14 27.57	0.078	21 14 38.25
Sunday.......	9	67.31	14 29 04	0.045	21 18 34.81
Monday.......	10	67 20	14 29.70	0.012	21 22 31.36
Tuesday	11	67.09	14 29.58	0.020	21 26 27.92
Wednesday ...	12	66 98	14 28.71	0.053	21 30 24.47
Thursday	13	66.87	14 27.07	0.083	21 34 21.03
Friday........	14	66.76	14 24.69	0 113	21 38 17.58
Saturday......	15	66.66	14 21.59	0.143	21 42 14.14
Sunday. ...	16	66.56	14 17.77	0.172	21 46 10.69
Monday	17	66.46	14 13.25	0.201	21 50 7.25
Tuesday....	18	66.36	14 8.06	0.229	21 54 3.80
Wednesday..	19	66.26	14 2.20	0.256	21 58 0.36
Thursday.	20	66.16	13 55.70	0.283	22 1 56.91
Friday	21	66 07	13 48.57	0.309	22 5 53.47
Saturday	22	65.98	13 40 81	0.335	22 9 50.02
Sunday........	23	65.89	13 32.45	0.361	22 13 46.56
Monday	24	65.80	13 23.47	0 385	22 17 43.13
Tuesday..... ..	25	65.71	13 13.93	0.409	22 21 39.68
Wednesday	26	65.63	13 3 81	0 432	22 25 36.24
Thursday	27	65.55	12 53 14	0.455	22 29 32.79
Friday	28	65.47	12 41.93	0 477	22 33 29.34

Mean time of the Semidiameter passing may be found by subtracting 0s.18. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	3 22 5.8
☉	Full Moon.........................	11 23 33.2
☾	Last Quarter......................	19 23 23.5
●	New Moon	26 15 22 5

		D. H.
☾	Apogee	11 15.6
☾	Perigee............................	26 2.0

Latitude of Harvard Observatory .... 42° 22′ 48″.1

	H. M. S.
Long. Harvard Observatory...............	4 44 29.05
New York City Hall................	4 56 0.15
Savannah Exchange.................	5 24 20.572
Hudson, Ohio......................	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D. H. M. S.	° ′ ″	H. M.
Venus........	1 23 52 52.23....	− 0 50 7.8.....	3 5.8
Jupiter.....	1 10 3 22.34....	+13 10 5.4.....	13 13.8
Saturn	1 19 51 23.71....	−21 3 22.6....	23 1.0

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CONTENTS.

Proportional Sizes of Wheels to Pinions, and of Pinions to Wheels, with the Distances which their Centres ought to have, so as to form proper Pitchings.

BY E. B. NICEWANER, BALTIMORE, MD.

Having experienced the time when I would have given almost anything I possessed to have known the correct or scientific rules for sizing wheels to pinions, and pinions to wheels for a given centre distance, and being of the opinion that there are others young in the craft who are now not unlike myself, and who take sufficient interest in their vocation to gladly avail themselves of any instructions or information that they may chance to meet with, is my humble excuse for offering the Journal the following propositions and rules, compiled from the best authors on scientific Horology, upon the subject under the above heading.*

To render a pitching the most perfect possible, and to avoid the inequalities of the curves of the teeth, pinions should be made with the greatest number of teeth or leaves, as of eight, ten, or twelve, etc.; by this means we reduce to the least quantity, the obstacles which arise from the driving before and after the line of centres, and the curves of the teeth becoming insensible, there results the least inequality, should they even be badly formed; for the pitching of pinions of six, requires care to have them well made, not only in determining the size, *which varies*, but in forming the curves exactly, and to avoid at the same time inequalities, butting, friction, etc.

To have a good safe pitching, much depends on the proper size or diameter of the pinion, on the figure of the wheel teeth, and of the pinion leaves; if the pinions are high numbered, that is, not less than eight or ten, any small deviation from a true figure may not be of so much consequence as some have attached to it.

With such small teeth as are in clocks and watches, in practice the figures of the teeth cannot well be drawn; nevertheless, our workmen and wheel-teeth finishers make the nearest approximation they can to the shape required; where this is well attained, it is wonderful how it prevents rubbing or wearing in the pinions.

In the sizing of pinions, it is no doubt desirable to have them as large in diameter as they can safely be admitted, and rules for this purpose have been given by several artists, which, from longer and more extended experience, have afterwards been given up.

The renowned horologer, Berthoud, says: "The best method to determine with the greatest precision, the size of a pinion for any wheel whatever, is, before hardening and tempering it, to put it with its wheel into a pitching tool; for this purpose some of the wheel teeth must be rounded off, when it will be seen by its pitching, if it is of a right diameter and figure; if it is too large, reduce it, till it comes so as to have the pitching made to move in as uniform a manner as possible; if it is too small, another must be made or the wheel reduced. But to

* Certainly no apology is necessary from our correspondent for thus presenting this subject. Mr. Grossmann is now engaged in preparing an essay for the Journal, on the cutting and sizing of wheels and pinions, which will probably be a valuable addition to horological literature.

We regret to state that an accident to the author of the Essay on Regulators prevented the preparation of the second chapter in time for the present number.

prevent this inconvenience, make use of the following methods, which serve to give the size as nearly as may be, to which a clock pinion ought to be turned before cutting it:

"Cut a slip of paper, whose breadth should be about that of the thickness of the wheel for which a pinion is required to be made, apply this slip of paper on the circumference of the wheel teeth, supposed cut, but not rounded off, and clip it to such a length as to take over as many teeth of the wheel, and two more than the pinion is to have leaves; the length of the slip of paper will be the measure for the circumference of the pinion."

If we have, for example, a pinion of 16 to make, cut the slip so as it will lay over 18 teeth of the wheel, then apply it around the pinion, which reduce in turning, till such time as the two ends of the paper slip meet on lapping it around.

"The pinion being afterwards cut and rounded up (but before tempering it), let some of the wheel teeth be rounded off, and fixing it on a smooth arbor, put the wheel and pinion into the pitching tool, and see if it is of such a diameter as will, with the teeth of the wheel, produce a regular smooth pitching."

With small pinions for clocks, and in those for watches, slips of paper cannot readily be made use of, but here are rules founded as well as the preceding, on experience, and agreeable to the practice of the best workmen.

When the teeth of wheels are cut, and the diameter of pinions are required to be taken from them, calipers, or spring pinion gauges, are used. If, for example, it is required to make a pinion of 16 teeth, or leaves, give an extent or opening to the calipers, or gauge, so as to take in 6 teeth of the wheel, taken from the outer flank of the first tooth to the outer flank of the sixth ; this is what is called six full teeth.

For a pinion of

15. The calipers must extend not quite to the flank of the sixth tooth.
14. Take 6 teeth on their points, or middle of their tops.
12. Five full teeth when it is for a large wheel of a clock, and when it is for a watch, take five teeth fully on their points.
10. Four full teeth.
9. A little less than four full teeth.
8. For a clock, four teeth on their points, less the fourth of a space of one tooth.
7. In a clock, three full teeth, and a fourth of a space of one tooth ; for watches, take a little less than three teeth of the wheel, when finished, by forcing the calipers over them.
6. For clocks, take three full teeth; for watches, a little more than three teeth on their points.
5. Three teeth on their points.
4. Take two square and full teeth. When the pinion leads, take two square teeth of the wheel, and a half of a space of one of the teeth more; in general, all pinions which lead, ought to be somewhat larger than those which are driven.

The pitching tool which Berthoud recommends for trying the pitching of a wheel and pinion, is that which, with us, is called the Geneva pitching tool, and has been long known and used in this country.

The great facility which this tool gives of seeing pitchings, repairing them, carrying them in a correct state to the frame plates of a clock or watch, renders this instrument very necessary to the workman ; it can be made use of in setting off various escapements, such as the anchor, cylinder, or horizontal one, duplex, chronometer, etc.

It has the advantage over the Sector tools (a kind of pitching tool invented and used about one hundred years ago ; made up in some degree on the principle of proportional compasses, which do not take in the wheels and pinions, by allowing the working of the pitching to be seen), and serves to check any pinion of an improper diameter, which may at times, by mischance, have been overlooked, both by the movement maker, and by the examiner.

One of the most simple yet accurate measuring instruments of modern introduction, whose divisions are perfectly decimal (which system is now almost or quite universally adopted by all scientists for scientific calculations), is the meter measure or sliding rule, its divisions are based upon the metrical system.

The meter measure is a kind of sliding rule with rectangular arms between which the objects to be measured are inserted.

The edge of the rule is divided by millimeters, and with the aid of the vernier the tenths of a millimeter can be read. The millimeter is about $\frac{1}{25}$ of the English inch, and about $\frac{2}{5}$ of the French line, thus giving the reader an idea of the dimensions of $\frac{1}{10}$ of a millimeter.

This instrument, the round micrometer, whose

divisions are also millimeters and hundredths of a millimeter, and the tenth measure, form a complete set of measuring instruments, which are quite sufficient for all practical wants of watch and clock making, and ought to be in the hands of every intelligent workman who takes sufficient interest and pride in his profession to desire to execute a piece of work scientifically, and with precision.

With the aid of this sliding rule I propose to show how the diameter of a pinion of a given number of leaves may be found from the wheel that pitches into it, and *vice versa*, having a pinion, required to find the diameter of the wheel of a given number of teeth that pitches into it.

Having lost a wheel and the pinion into which it pitches, required to find what should be the diameter of each, with a given number of teeth in the wheel and leaves in the pinion, so as they may be made to pitch properly together at the given centre distance, and *vice versa*, having a wheel and the pinion into which the wheel pitches, required to find their centre distance so as to insure good pitching.

Of course it must be understood that the more perfect the figure of the wheel teeth, and pinion leaves, *i. e.*, the nearer they approach the true epicycloidal curve, the more uniform and perfect will be their action.

It is supposed to be a settled point, that two and a quarter may be taken for the addenda on a line of equal parts, over and above the number of wheel teeth when the wheel drives the pinion; and for the pinion one and a half more than the number of leaves which it contains. But when the pinion leads the wheel, the addenda for it must be two and a quarter, and that for the wheel one and a half.

All that is necessary in making use of this sliding-rule is, the workman must have some little knowledge of the rule of proportion, and of decimals; by it the size of the pinions may be had before the wheels are made, or give the diameter of the wheel to a given pinion. Clock-makers, before making their pinions, are in the practice of first having their wheels cut; as it is from the teeth and spaces they get the diameter of their pinions.

By the proper use of this sliding-rule, the pinions may be made at any time, whether the wheels are made, cut or not cut.

Clock and watch makers have different methods for taking the diameter of pinions, as well as different sizes. Some take more or less of teeth and space by the pinion gauge than others do, and the greatest accuracy by this way is not quite attainable, unless having very extensive and nice practice. If no mistake is made in calculation, the sliding-rule will give these things with the greatest degree of precision.

Before giving the examples for sizing wheels and pinions, I will present a few rules by the earliest artists for finding the diameter of pinions from the wheels in which they pitch.

The rule which Mr. Hutton (in his introduction to the mechanical part of clock and watch making) has given for finding the diameter of pinions, will make them too large; and that which is given in a very respectable work (Rees' Cyclopedia) will make them larger still. The rules are nearly the same in both, only Mr. Hutton's addenda is 1, and that of the other is 1.5.

Multiply the number intended for the pinion by 2, then divide the product by 3, and to the quotient add 1, or 1.5, as they may apply, and this will be the diameter in teeth and spaces taken from the wheel which is to drive the pinion. An example shall be taken in both cases for the diameter of a pinion of 8 leaves.

$$8 \times 2 = 16 \div 3 = 5\tfrac{1}{3} + 1 = 6\tfrac{1}{3}$$
$$8 \times 2 = 16 \div 3 = 5\tfrac{1}{3} + 1.5 = 6.8.$$

Although the rule now to be given differs not very materially from the two last, yet it will be found to be a good one, and give such diameter to the pinions as will at all times and cases insure safe pitching. Multiply the given number of pinions by 2, to the product add 1, and then divide by 3, the quotient will be the diameter required. Take the former as an example,

$$8 \times 2 = 16 + 1 = 17 \div 3 = 5\tfrac{2}{3}.$$

being three teeth, two spaces, and two-thirds of a space, taken by the calipers from the teeth of a wheel not rounded up, and which will be a diameter sufficiently large.

In taking the diameter for a leading pinion, it will make but a very small difference, wheth- the addenda is two, or two and a quarter. For a pinion of 8, the diameter in the one case is 6, and in the other 6.08.

The diameter of the centre wheel in a fine

watch being fourteen millimeters, and ninety hundredths of a mill. (14.90) having 80 teeth, and the pinion which it is to drive has 10 leaves, it is required to have the diameter of the pinion, so as they may pitch properly together?

Say as 80 teeth + 2.25 (the addenda for the driver) = 82.25 is to 14.90, the diameter of the wheel, so is 10, the pinion leaves + 1.5 (the addenda for the driver) = 11.5 to χ, a fourth number, which will be that for the diameter required.

```
Then as 82.25 : 14.90 : : 11.5 : x
                 11.5
                -----
                 7450
                1490
               1490
        82.25 )171.350 (2.08+
               16450        The number required for the
               -------      diameter of the pinion, say 2
                68500       mill. and .08 hundredths of a
                65800       mill.
                -----
                 2700
```

The diameter of any wheel (by having the diameter of the pinion) may be found in the same way as that of the pinions. The diameter of the centre wheel pinion in a watch being 3.75, and having 12 leaves, the great wheel to have 96 teeth: Required the diameter? Say as 13.5 : 3.75 : : 98.25 : χ, or 27.29, the diameter which the great wheel ought to be.

The diameter of a centre wheel of a watch being 14.90 having 80 teeth, and the pinion which it is to drive has 10 leaves: Required the distance their centres should have, so as they may pitch properly together? Say, as 82.25 is to 14.90, the diameter of the wheel, so is half the sum of the wheel and pinion added together, to a number which shall be the distance required, 80 + 10 = 90, half of which is 45; then 82.25 : 14.90 : : 45 : χ, or 8.15, the distance which the centre ought to have, which is 8 millimeters, and 15 hundredths of a mill. Supposing the centre wheel to be lost, as also the third wheel pinion, having the distance of their centres, to find what should be the diameter of each, so as they may be made to pitch properly together at the given distance of their centres? The distance given is 8.15 the centre wheel is to have 80 teeth, and the third wheel pinion to have 10 leaves. To find the diameter of the centre wheel, say, as 45 (which is half of the sum of the 80, and the pinion 10, added together) is to 8.15, so is 82.25 to the diameter required.

```
45 : 8.15 : : 82.25 : x
              8.15
             -----
             41125
             8225
            65800     Dia. of the wheel.
           --------
       45)670.3375 (14.8963
          45
          ---
          220
          180
          ---
           403
           360
           ---
            433
            405
            ---
             287
             270
             ---
              175
              135
              ---
               40

45 : 8.15 : : 11.5 : x
              8.15
             -----
              575
             115
            920
           ------
       45)93.725 (2.082
          90           Dia. of the pinion.
          ---
          372
          360
          ---
           125
            90
           ---
            35
```

In conclusion I would mention that the above measuring instruments spoken of, the meter measure, round micrometer, and tenth measure are manufactured by Mr. Moritz Grossmann, a very eminent watch manufacturer in Glashütte, Saxony. A complete set of these instruments, or any one of the set can be had in this country.

———o———

Kelley's Watch Oil.

Every watchmaker fully understands the importance of good oil, knowing that no work will give satisfaction without it, and will be glad to learn that Mr. Kelley has taken the necessary steps to protect himself against the frauds of unscrupulous dealers by affixing a trade mark to the label of each bottle.

Principles and Laws of the Isochronism of the Vibrations of the Balance by the Hairspring.

Translated from the works of FERDINAND BERTHOUD

BY THEO. GRIBI, WILMINGTON, DEL.

INTRODUCTION.

There is, among the better class of workmen throughout the country, an interest manifested in the subject of isochronism, perhaps more than in any other relating to practical horology. The want of a more thorough and satisfactory elucidation than has hitherto appeared in English print on the matter, has been repeatedly expressed by various correspondents. While it is not the writer's desire to undervalue the labors of those who have kindly favored us with their experience so far, and while nothing could be too much to be said that would in a measure throw light upon the subject, yet it must be confessed that much that we have received from those who profess to know, is lacking in the first principles upon which the adjustment is based, while others are mere abstract notions, more or less confused.

It is for these reasons, and from an humble desire to enrich our stock of knowledge as well as to aid and encourage the efforts of the intelligent workman, that a translation of the writings of the celebrated artist, Ferdinand Berthoud, is proposed; first on the above subject, and afterward, if desired, on other matters.

It is true that the works of this artist are for the most part over a hundred years old, and that the chronometrical constructions to which he then applied his reasoning have now become obsolete; still, in the fundamental principles, our modern artists have made but little if any advance, the main difference of the present time consisting in the application of those principles to smaller and less complicated mechanisms. Besides, I know of no modern works extant, save one or two on particular themes, which are so thorough, exhaustive, and comprehensible; and since, to my knowledge, no English translation of these works as yet exists, it is the more to be expected that the present, though a mere fragmentary one may receive the approbation of the reader.

It was at first thought that a literal translation would be superfluous and too long, and, in fact, were his entire works to be translated in the JOURNAL, it would fill its columns for more than a year. To obviate this, it was proposed to collect the most useful portions from his principal works, revise and modernize them, and thus publish a condensed treatise in a series of consecutive articles; but on more mature deliberation this plan was abandoned, mainly for two reasons: one was, that such an undertaking would be too laborious; and the other, and perhaps the more urgent one, is, that any attempt to abbreviate or modernize could but detract from the value of the original, and would thus prove a rather poor tribute to the memory of the esteemed and celebrated author. It was then concluded to translate literally some of the leading and most useful portions, as much as is required, in separate articles, and since frequently retrospective references occur, to use even the numbers of the paragraphs as they are in the original. The present subject is taken from the work entitled "TRAITÉ DES HORLOGES MARINES," dedicated to and published by the order of his Majesty Louis XV., A. D. 1773.

To such as may be interested to know something of the nature and character of the book, we may say that this work, which is one of a valuable collection of the same author, is a volume of 590 pages, together with 27 plates of engravings. Its chief aim was, as may be inferred from its title, to lay before the artists and horological amateurs of that time, a complete and comprehensive account of his labors and researches in the pursuit of practical horology, and particularly in the construction of what were then called Marine Clocks, designed especially to determine longitude at sea, and which we now call ship chronometers. The size and proportions of these machines, as will be seen, differed widely from our modern ones. An idea of the difference may be inferred from the fact that he sometimes employed one or two balances a foot or more in diameter, and weighing several pounds. Such a balance had to be suspended at its axis by a thin steel spring, capable of twisting considerably, and each extremity of the staff, instead of moving by pivots in holes, rolled between three friction rollers of large dimensions, by which means the resistance to the vibrations of the balance was reduced to a minimum. Of course such a balance required a spring in proportion, many of

which we would probably consider to be pretty good size clock mainsprings. In the course of these articles it will be seen that he sought to obtain isochronism by various means; chiefly by making the spring of a certain taper from the centre outward, by making it longer or shorter, and by coiling it closer or looser.

In order to determine the isochronal property of springs before applying them to the balance, he constructed an instrument which he called "Balance élastique," by means of which he measured the forces of springs at different degrees of inflection. Though the description of this instrument is in another part of the book, apart from this subject, we shall give it in the course of these articles.

It will be well for the student to study particularly paragraph 141, possibly necessary to get the assistance of some person versed in the physical laws of motion, if he desires to comprehend well the subject, for those are the principles on which is based the theory of isochronism. It is impossible to state scientific truths, except in scientific terms; if we wish to understand them, we are obliged to trouble our mental powers considerably sometimes, or we lose the thread of the reasoning.

F. Berthoud was a contemporary of Mudge and Harrison. He was the first after Sully and Le Roy, who, in France, labored in the construction of proper machines by which to determine longitude at sea, and his writings, though old, are still very valuable, displaying a purity of devotion to the interest of his science, a comprehensiveness and soundness of reasoning, together with an untiring patience in describing the smallest minutiæ of practical manipulations not surpassed by modern writers.

With this brief sketch, and begging the indulgence of the patient reader, we will now proceed to the translation.

137. The application of the hairspring to the balance is one of the most fortunate discoveries the science of Horology has made; we owe it, as well as that of the pendulum, to Huyghens. Still, the hairspring, such as it was, was the cause of considerable deviations in the rate of chronometers.* 1st. It has been found by experience that heat diminishes the elasticity of the spring, and cold increases it; so that a chronometer to which it has been applied loses in warm and gains in cold temperatures. 2d. I have ascertained by decisive experiments that great and small arcs of vibrations of a balance are not isochronous, and that generally, in the case of a free balance, great arcs are performed quicker than small ones; so that, as soon as a balance describes greater and smaller arcs, the chronometer will vary, and that this effect is produced by the action of the hairspring. I am now going to treat on the principles which have led me to render the unequal arcs of vibrations of the balance isochronous, an object of very great value in the construction of chronometers.

138. The inequality in the arcs of vibration of a balance in chronometers may be produced by two principal causes: 1st, by inequalities in the motive force, in the train, in friction, in the resistance of the oils, etc.; 2d, by the external motion of the vessel. But if the regulator † does not possess a property such as will cause the great and small arcs of vibrations to be performed in equal time, the result will be that the chronometer varies considerably as soon as, by the one or the other cause, the arcs are changed in extent.

139. By a particular combination in the escapement we may obtain the means of obviating the variations of a chronometer caused by unequal arcs of vibration, inasmuch as this inequality is produced by changes in the motive force; but even if such an escapement should constantly preserve this property, it could only serve to correct the inequalities in the action of the motor, but not the variations of a chronometer caused by unequal arcs of vibration of the balance, when this inequality of vibrations is produced by the agitations of the ship; for, if an agitation of the ship should increase the extent of a vibration, and the nature of the regulator be such as to cause great arcs of vibration to be performed slower than small ones, the result will be that, the motive force remaining the same, the escapement will have no power or property to oppose this increase of the arc of vibration, nor to cause it to be performed quicker, the duration of such vibration would thus

* The word "Horloge" properly means a timepiece, but as a timepiece does not convey the proper idea, we shall always translate it by "Chronometer."

† By the word "regulator" the entire system of balance and hairspring is designated.

necessarily be longer, whereas, if the greater vibration had been produced by the motive force, the escapement, being supposed isochronal, would have shortened it.

140. If, on the other hand, we suppose the greater arcs of vibration to be of shorter duration than the small ones, in order that the escapement should render them isochronal, its construction would require to be different from that in the first supposition; for it would be necessary that the escapement allow the vibrations to be completed without opposing any resistance, and that, on the contrary, in the return, it cause the wheel to recoil; but with such an escapement, the same as with the preceding one (139), the result will be to render isochronal only those vibrations which had for cause of their inequality a variable motive force, and not at all those which are the result of agitation of the vessel; thus, from whatever side we may view the matter, it will be seen that it is impossible to construct an escapement such as to render isochronous other vibrations of the balance than those whose source of inequality is in the motor itself. It is therefore absolutely necessary to seek this property of isochronism in the oscillations of the balance itself; for, the vibrations of the regulator being by their nature isochronous, they will remain so whatever may be the cause of their greater or less extent, and then we need only require of an escapement the property of not disturbing the oscillations of the balance. Such reflections as these have convinced me that isochronism of the vibrations cannot be obtained by an escapement, but in the balance itself only.

FIRST PROPOSITION.

How the isochronism of the vibrations of a balance is produced by a hairspring.

(84.* If two different balances are composed of equal masses, and move with unequal velocities, their forces will be as the square of their velocities: thus, if the velocity of a balance A=1, and that of a balance B=5, the force of the balance A will be to the force of the balance B, as 1 is to 25; therefore, the action required to give motion to the balance A, is to that required to give motion to the balance B, as the force of A is to the force of B, or as 1 is to 25.)

141. If we have a simple balance without hairsprings which we desire to describe alternately great and small arcs in the same time, it will be necessary that the force or power which is to give motion, vary as the squares of the arcs (84). Therefore, if, instead of a power, we substitute a hairspring, it will be required that the progression of its force be such that, for all corresponding arcs, the products of its force augment in the same proportion as that of the balance. In such a case its oscillations will be isochronous. If then the arcs described by the balance are 0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, 100°, 110°, 120°, etc., or which is the same thing, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, etc., the forces of its motion corresponding to these arcs will be 0, 1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 121, 144, etc.; therefore, to be isochronal, the powers of the hairspring corresponding to these arcs will require to augment in this last proportion. Now, if the ascending force of the hairspring is in arithmetical progression, so that we shall have the following two progressions:

Arcs described by the hairspring . .	0,	10,	20,	30,	40,	50,	60,	70,	80,	90,	100,	110,	120
Force, or weight required to make equilibrium . .	0,	1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	11,	12

then I say that the products of these forces of the hairspring when in motion, for all the corresponding terms of these arcs, will be as the square of the arcs, which is a consequence of their property of being in arithmetical progression. Thus the vibrations of any balance whatever to which this hairspring may be applied, will be of the same duration, whether the balance describe great or small arcs; which is evident from the fact that the powers of the given hairspring follow the same law as the augmentation of the force of bodies in motion.

It is to be distinguished between the FORCE of bodies when in motion and the FORCE when in equilibrium; for, the weights that make equilibrium with the hairspring during any number of ascending arcs, augment simply as the arcs,

* This paragraph, found in another part of the book, we allow to precede in parentheses, because it is alluded to in, and important in order to understand, the following paragraph.

whereas the force or power of the same hairspring when in motion, is expressed by the square of the arcs; for here this force is not merely the quantity of weight that makes equilibrium, but it is composed of the sum of the forces or weights employed to cause the spring to move over all the intermediate arcs, from zero to the actual point of equilibrium; now, these weights being in arithmetical progression, their sum, which is equal to the force or power of the spring when in motion, augments as the square of the arcs described.

SECOND PROPOSITION.

142. This quality in a hairspring may be obtained by making it longer or shorter, as may easily be proved. If we have a very long and very weak hairspring, so that it may be wound to a great many revolutions, as for instance 10, and supposing moreover that, being entirely wound up, its force will be double of that when it is within one turn run down, then during the first turn of winding it, its force will augment about $\frac{1}{10}$ of the total force, and the ascending progression of its force will be insufficient to follow the law of the square of the arcs; thus, in applying such a hairspring to a balance, its oscillations would not be isochronal; during great arcs, they would be slower than during small ones.

143. If, on the contrary, we make this same hairspring very short, so that it could be wound but a very few turns, then the progression of its force would augment in a greater proportion than is required for its isochronism; thus the vibrations of great arcs would be of shorter duration than those of small arcs.

144. Since a hairspring, such as we suppose here, would cause the vibrations of great arcs to be slower than those of small arcs, being very long (142), and being shorter, the vibrations of great arcs would, on the contrary, be faster (143) than those of small arcs, it follows that a point exists in this same spring between these two extremes of lengths, at which, being fastened, it will cause vibrations of great and small arcs to be isochronal, or of equal duration; and this is the point where the hairspring, being held in equilibrium by weights, will have a perfectly arithmetical progression of force; for in this case the sums of its forces will be among themselves (when in motion), as the squares of the arcs.

THIRD PROPOSITION.

The oscillations of a balance will be still isochronal after the application of the escapement.

145. After what I have said now, we can easily conceive the possibility of producing this essential property of isochronism in the case of an isolated balance; but there will be not more difficulty in establishing it after it will be in connection with the escapement in the chronometer; it is even only in this latter case that it is possible to ascertain whether the vibrations are perfectly isochronal or not, and whether they are not disturbed by the friction of the balance or by the escapement itself. I have made an instrument, which I call elastic balance, by means of which I am enabled to determine, with the greatest precision, the ascending force of the hairspring, so that, if the force of a spring follows the required law, and afterward, being applied to the balance with the escapement, the vibrations are not isochronal, it will prove that the cause of it is attributable to a defect elsewhere than in the spring; thus, experiments with a chronometer in a finished state will enable us to determine exactly the quality of an escapement, as well as disturbing causes of other nature.

FOURTH PROPOSITION.

A hairspring of whatever force, having the progression required by the law of isochronism, will preserve this property, whether it be applied to a balance of quick vibrations or to one of slow vibrations.

146. 1st. If we have a hairspring, the ascending progression of whose force is perfectly in arithmetical progression, it is evident by the nature of this progression, that the sums of the forces augment as the squares of the inflections, and that consequently the hairspring will follow the law required for the isochronism.

2d. The same spring will preserve its property of isochronism to whatever balance it may be applied, whether to a large or small one, to a heavy or light one; for it is upon the mass of the balance and its diameter, the spring being given, that the nature of the vibrations depend, whether they will be slow or fast. If we adopt such an isochronal hairspring to a heavy

balance, its vibrations will be slow, and, on the contrary, if the balance is small and light, its vibrations will be quicker; but the forces of the balance and the hairspring preserve between themselves the same relation in these different cases, for, in any given balance, the force augments always as the squares of the arcs described, and in an isochronal hairspring the sums of its forces augment in the same proportion. These are the principles which necessarily constitute the nature of the vibrations, whether they will be slow or quick. But if the balance were given, as also the number of its vibrations, then we would be obliged to cause it to make that given number of vibrations by a greater or less force of the hairspring. The force of the spring being given, whatever it may be, it will always be possible to change its progression; this will depend upon its length, its strength, its shape, and the number of its coils, as we shall prove hereafter.

147. If it were desired that, in an isolated balance describing great arcs, the oscillations should be perfectly isochronous from the smallest vibrations to the largest, it would be necessary for the hairspring not only to have the required length, but also that its shape be accordingly, so that its progressive force be perfect in every point. But this extreme accuracy is hardly necessary in the practical application of the balance; for, below the degrees of leverage the chronometer would stop, and consequently the inequality in the arcs cannot go so far.

148. It is nevertheless well to observe, that we should give to the hairspring the proper dimensions necessary to obtain the desired progression of force for all its degrees of inflection, counting from zero, where it is at rest, up to the greatest inflection which it is possible for the balance to give it; for, after more careful reflection I find that if the progression of its force were not perfect below the degrees of leverage as well as above, the oscillations would not be isochronous for all the arcs of vibrations even above the degrees of leverage; this is evident, since it is necessary for the isochronism that the sums of the forces employed to wind the hairspring up are as the squares of the arcs described. Now, according to this, if below the arc of leverage the progression were smaller than it ought to be, that is, if it were not an arithmetical progression, the sums of the forces during the greater arcs would augment in a greater ratio than the square of the corresponding arcs, so that the vibrations of the greatest arcs would be of less duration than those of the smallest; that is, the chronometer would gain during its greatest vibrations and lose during the smallest ones, although above the arc of leverage, the ascending progression of the force of the spring may be arithmetical.

149. To give this isochronal property to a hairspring, I have said that it was depending upon its length, its shape, and the number of its coils; this we shall prove hereafter by reasoning and experiments. It will then be seen that to make a spring a little longer or a little shorter, changes its progression. This length being determined, the hairspring having the requisite progression, we should not then, as is commonly done in watches, lengthen and shorten the hairspring in order to regulate the chronometer; this would destroy the isochronal property of the spring; on the contrary, we should make the balance heavier or lighter until the chronometer were regulated; or, if we do not wish to alter the balance, we can make a new hairspring which will combine the desired force with the requisite progression. But if we have been able once to make an isochronal hairspring, which, when applied to a balance, had the required force, etc., whenever we wish to have a balance of the same dimensions and number of vibrations, the dimensions of the hairspring will also be given, and it will be easy to give it the force and the progression required for isochronism.

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Fifteen Hundred Dollars for One Hundred.

Mr. Geo. W. Dickinson, of Ashtabula, Ohio, sends us a letter he received from Mr. Robinson, 18 Bond Street, N. Y., stating that some months since a young man came to his office with a large quantity of jewelry and silver-plated ware, said to be worth \$1,500, on which he wanted to borrow \$75, since which time he has never seen him. He fears the goods might have been stolen, and dares not offer them for sale in the city, therefore offers to send the entire lot by express, C. O. D., for \$100.

George says, "that's too thin."

ABSTRACT OF THE PRINCIPAL CHANGES OF RATES OF CHRONOMETERS

Name of Maker.	No.	Address of Maker.	Construction of Balance.
Kullberg	1799	105 Liverpool road, London	Kullberg's flat rim balance, without auxiliary
Hennessy	4793	5 Wind street, Swansea	Auxiliary compensation
McGregor & Co	4173	Clyde place, Glasgow	Ordinary auxiliary compensation to balance
Lowry	779	66 High street, Belfast	Auxiliary compensation
Parkinson & Bouts	1129	59 Gracechurch street, London	Auxiliary acting in extremes of temperature
Glover	354	8 Wrotham rd., Camd. New Town, Lond.	Auxiliary as before
Isaac	1120	147 Liverpool road, London	Original construction of balance without aux.
Usher & Cole	457	46 St. John's square, Clerkenwell, Lond.	Auxiliary to balance
Glover	332	8 Wrotham rd., Camd. New Town, Lond.	Auxiliary as before
Kullberg	1885	105 Liverpool road, London	Improved ordinary balance
Davison	4765	6 Side, Newcastle-upon-Tyne	Auxiliary compensation
Sewill	3040	61 South Castle street, Liverpool	Auxiliary compensation
Chittenden	793	10 Wilton road, Hackney, London	Auxiliary as in former years
Parkinson & Bouts	1171	59 Gracechurch street, London	Auxiliary acting in extremes of temperature
P. Birchall	1150	12a Stonefield street, Islington, London	Ordinary balance, with a slight alteration
W. P. Birchall	271	12a Stonefield street, Islington, London	Ordinary balance, with a slight alteration
Carter	715	61 Cornhill, London	Ordinary balance, with a slight addition
Wells	3531	22 High street, Newport, Monmouth.	Auxiliary to balance
Carter	739	61 Cornhill, London	Ordinary balance
Shepherd & Son	1787	53 Leadenhall street, London	Auxiliary to balance
McGregor & Co	4571	Clyde place, Glasgow	Pool's auxiliary
Williams & Co.	97	2 Bute Docks, Cardiff	Auxiliary compensation
Gowland	2274	178 High street West, Sunderland	Auxiliary compensation
Hennessy	4796	5 Wind street, Swansea	Auxiliary compensation
Reid & Sons	1215	41 Gray street, Newcastle-upon-Tyne.	Auxiliary acting in cold
Sewill	3039	61 South Castle street, Liverpool	Auxiliary compensation
Quilliam	17917	32 Elizabeth street, Liverpool.	Continuous auxiliary to balance
Whiffin	361	10 Cloudesley square, Islington, Lond.	Auxiliary compensation
Brotherton	5417	11 Spencer street, Goswell road, Lond.	Construction as in former years
Russell & Son	2089	30 Slater street, Liverpool.	Auxiliary to balance
M. F. Dent	26440	33 Cockspur street, London	Mr. F. Dent's new compen. balance without aux.
Shepherd & Son	1761	53 Leadenhall street, London	Auxiliary to the balance
Hammersley	1708	54 Spencer street, Clerkenwell, Lond.	Auxiliary compensation
Dell & Co	19368	Broad street, Bristol	Auxiliary compensation
Highley	5435	45 High street, Sheerness	Auxiliary acting in cold
Hammersley	1589	54 Spencer street, Clerkenwell, Lond.	Auxiliary compensation
Isaac	1122	147 Liverpool road, London	Auxiliary compensation for heat
Whiffin	358	10 Cloudesley square, Islington, Lond.	Auxiliary compensation
Parkinson & Frodsham	4033	4 'Change alley, Cornhill, London	Auxiliary permanently in action
Reid & Sons	1492	41 Grey street, Newcastle-upon-Tyne	Auxiliary acting in all temperatures

The chronometers are placed in order of merit, their respective positions being determined by consideration of the irregularities of rate exhibited in the table above.

All the chronometers were two days. The lowest temperature in which they were tried was 44°, the highest 95°.

We have just received an abstract of the last annual report of the Astronomer Royal, concerning the yearly competitive trial of chronometers at the Greenwich Observatory, which we publish herewith. It will be perceived again with what pertinacity the subject of an improved construction of compensation balance is pursued by the different English makers, contributing to this annual tournament in chronometry; and in this connection it is noticeable that but one chronometer, in the entire list of forty, was furnished with the "ordinary balance" without alteration, with this exception, all having been provided with some form of attempted improvement, consisting in some instances of a slight alteration to the original balance; in others, of a new construction without auxiliary, as in the cases of Messrs. Kullberg and F. Dent, but generally the improvement has been of the variety known as balances with auxiliaries. The latter may be divided into three classes, namely: 1. Those acting only in cold, and which, it seems to our mind, would be more properly described as a *check* acting in cold,

ON TRIAL AT THE ROYAL OBSERVATORY, GREENWICH, 1872.

Least Weekly Sum.	In what temperature.	Greatest Weekly Sum.	In what Temperature	Difference between the Greatest and Least.	Greatest Difference between one Week and the next.	In what Temperature.
s.	Degrees Fahrenheit.	s.	Degrees Fahrenheit.	s.	s.	Degrees Fahrenheit.
+ 3.6	44 to 48	+14 2	66 to 79	10.6	2 8	44 to 48
+ 1.5	do.	+ 8.9	64 to 70	7.4	5.1	51 to 63
+ 3.6	80 to 91†	+12 9	52 to 57	9.3	4.6	50 to 81
− 2.7	50 to 55	+ 8.4	64 to 70	11.1	4.6	do.
−13.1	44 to 48	− 1.4	50 to 55	11.7	4 6	95 to 67
−18.5	80 to 95†	− 5.8	48 to 52	12.7	4.3	79 to 91
+ 0.8	48 to 81†	+14.0	67 to 74	13 2	4.3	48 to 54
− 0 1	67 to 74	+ 9.7	50 to 55	9.8	6 2	50 to 81
−10 0	49 to 61	+ 1 3	44 to 48	11 3	5 9	do.
+ 4.0	44 to 48	+19.0	52 to 70	15.0	4.5	95 to 67
+ 5.5	do.	+18 0	51 to 61	12.5	5 9	54 to 89
− 9 2	48 to 52	+ 6 5	68 to 79	15.7	4 4	50 to 81
−11 2	61 to 81†	− 2.4	51 to 60	8.8	3.1	51 to 63
− 1.0	64 to 95†	+12 3	54 to 61	13 3	5.9	95 to 67
+10.8	67 to 74	+20.8	49 to 54	10.0	7.8	50 to 81
− 8.1	44 to 48	÷ 6.1	51 to 60	14.2	5 9	83 to 49
− 2.4	82 to 95†	+ 7.0	64 to 70	9.4	8.4	95 to 67
−27 0	47 to 54	− 6.2	82 to 95†	20.8	4.8	61 to 82
−26.8	66 to 79	− 5.0	50 to 55	21.8	5.8	95 to 67
−12.5	82 to 95†	+ 3.5	54 to 63	16.0	10.1	do.
−12.8	50 to 55	+ 0.1	67 to 74	12 9	12.1	do.
+13.8	do.	+33 4	52 to 57	19.6	9.1	do.
−10.0	82 to 95†	+ 6 5	49 to 59	16.5	10.8	54 to 89
− 8.7	do.	+ 7.6	53 to 60	16 3	11.1	95 to 67
−10.0	do.	+10.5	51 to 60	20.5	9 6	do.
−12.7	47 to 54	+ 4 6	64 to 70	17 3	11.2	50 to 81
− 9.5	44 to 48	+10.2	66 to 79	19.7	11 3	do.
−11.0	46 to 51	+16.1	64 to 70	27.1	8 0	95 to 67
− 9.6	48 to 52	+13.9	51 to 60	23.5	9.9	47 to 55
+ 9.5	65 to 83	+31.0	48 to 52	21.5	15.7	50 to 81
−22.4	52 to 57	+ 8.0	44 to 48	30 4	12.4	61 to 82
−21.2	56 to 88†	+ 4 8	52 to 57	26.0	15.7	50 to 81
−36.9	66 to 79	+ 3 9	47 to 54	40.8	8.5	95 to 67
−10.8	61 to 81†	+13.5	44 to 48	24 3	17.4	50 to 81
−12.8	82 to 95†	+12.5	53 to 60	25.3	18.0	95 to 67
+13.1	44 to 48	+62 0	66 to 79	48.9	6.4	do.
− 1.3	do.	+30.6	82 to 95†	31 9	15.0	54 to 89
− 1.4	do.	+35 5	67 to 74	36.9	12.7	do.
−10.9	51 to 60	+17.8	48 to 52	28.7	20.5	83 to 49
−21.5	64 to 70	+ 7.0	82 to 95†	28.5	25.5	95 to 67

The sign + indicates that the rate is gaining.

† During these weeks the chronometers were placed in the chamber of a stove heated by jets of gas. The gas flames are exterior to the chamber, into which none of the injurious products of combustion can enter.

The ratings commenced January 13th, and ended August 3d, so that the duration of the trials was 29 weeks.

Poole's auxiliary being of this nature. 2. Auxiliaries acting only in heat. 3. Those in which the action of the auxiliary is continuous in all temperatures, and of which class Prof. Hartnup's balance may be taken as an example.

It would appear, from the all but entire exclusion of the ordinary balance from this competition, that it was falling into disuse, which, however, is true only in connection with these trials; for it is a well-known fact, that the various improvements mentioned are so rarely seen in those chronometers made and sold purely for commercial purposes, that we would be almost justified in saying they are never so used, probably on the principle that race horses only are shod with steel, and for the reason that the mere cost of construction of these balances is considerably enhanced, and the extremely accurate adjustment of the improvements so difficult as to render it unprofitable as a regular matter of business. All this weighs as nothing in the severe struggle for supremacy at the Greenwich Observatory, for, so that the contestant stand sufficiently high on the list to

insure that his chronometer will be deemed worthy of purchase, and he thereby be authorized thenceforth to advertise himself "Maker to the Admiralty," no exercise of his subtlest ingenuity, no laborious experimenting, no painstaking in execution of details, no expense, nor any honorable consideration is allowed to stand in the way of a laudable desire for the attainment of the highest honors bestowed on his craft.

Every year we notice many chronometers in the list that are so decidedly poor that the wonder is the owners ever submitted them to a public test; and it not unfrequently happens that the name of some illustrious maker, often occupying a high position in the scale of merit, is sometimes found where little credit is to be gained. Perhaps this is only illustrative of the very considerable element of uncertainty that enters into the problem of accurate measurement of time; but, whether of chance or reasons that might be avoided, it seems to so distribute the honors that many bear them in equal degree, and all are encouraged in an honorable strife.

While upon this subject it will be pertinent to examine some of the causes of failure in chronometers arising from imperfect compensation for different temperatures, and for this purpose we have selected extracts from some of the annual reports of Prof. John Hartnup, of the Liverpool Observatory, who has probably given more attention to this particular branch of inquiry than any other person.

"The improvement of the ordinary chronometer balance has occupied the attention of chronometer makers so much during the past twenty years, that any information which has a tendency to show its defects, and the efficiency of improvements, will, I think, be interesting to your readers. It has for a long time past been known that chronometers with the ordinary balance, if compensated for 50° and 80°, will, on exposure to 20° or 110°, lose much more in either of the latter, than in the former temperatures. The loss in such extremes is generally so large that no refined means of testing are required to detect it. For the practical purposes of navigation we are, however, more immediately interested in the efficiency of the balance for those temperatures to which ships are generally exposed at sea." * * * *

"A few years ago I tested some chronometers, in which the balances were opened at two points 90° from the end of the arm, and four weights used instead of two, and the tendency to lose at the two extremes was certainly much less than in some balances opened in the ordinary way which I tried with them."

This was probably the balance invented and patented by the late Mr. John Bliss, father of the gentlemen constituting the present house of Messrs. John Bliss & Co., who have continued to use this balance until the present time, on account of the advantage alluded to. Their records of trials of large numbers of chronometers with balances of the usual pattern, contrasted with similar records of chronometers having this form of balance, show a decided superiority in favor of the latter, and, of course, a confirmation of Prof. Hartnup's tests.

"A faithful record has been kept of the performance of all timekeepers which have passed through our hands from the day that the Observatory was opened to the present time, and abstracts of results have, from time to time, been published. These abstracts have, however, always related to the performance of chronometers on shore; no account has been given of their errors at the terminations of voyages of different lengths. The delay in giving such information has been caused by the difficulty in obtaining a sufficient number of examples to allow conclusions of a trustworthy nature to be drawn from them. When ships' chronometers are sent to the Observatory, it is, of course, optional on the part of the Captain as to whether he furnishes us with the *error* and *rate* supplied to him at the last port from which he sailed, and in a large proportion of cases this information has not been available to us; but in all cases in which it could be obtained we have tabulated the results, and we have now on record the error in longitude by chronometer for between one and two thousand voyages, ranging in time from a few weeks to twelve months and upwards.

"In order to render the information thus obtained available for comparison, we have taken averages at intervals of two or three months; and then, by interpolation, the mean errors have been found for each month, from one to twelve inclusive. In the following table the first column shows the length of voyages in

months, the second column contains the average error of longitude in minutes of arc, or in geographical miles on the equator, as deduced from 1,700 chronometers; the remaining columns show the average error of the best ten, second best ten, third best ten, etc., in one hundred, the last column showing the mean error of the worst ten in one hundred.

Error of Longitude in Geographical Miles on the Equator, Deduced from 1700 *Chronometers.*

Length of voyage.	Average error deduced from 1700 Chronometers.	The best 10 in 100.	Second best 10 in 100.	Third best 10 in 100.	Fourth best 10 in 100.	Fifth best 10 in 100.	Sixth best 10 in 100.	Seventh best 10 in 100.	Eighth best 10 in 100.	Ninth best 10 in 100.	The worst 10 in 100.
	Miles.	Miles	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
1 month......	6	0	1	1	2	3	4	5	7	9	25
2 months.....	14	0	2	4	5	7	9	11	15	24	62
3 months.....	23	1	3	6	9	12	15	18	25	41	101
4 months.....	33	1	4	8	13	17	22	28	36	61	143
5 months.....	44	1	5	10	17	22	29	39	49	84	187
6 months	56	2	6	13	21	28	37	50	64	108	233
7 months....	69	2	8	16	25	34	46	62	80	134	280
8 months.....	82	3	10	19	30	41	55	74	98	159	328
9 months.....	95	3	12	22	35	48	65	86	117	184	376
10 months.——	108	4	14	26	40	56	75	98	137	208	425
11 months.....	122	4	16	30	46	64	86	111	157	233	474
12 months.....	136	5	18	34	52	72	97	124	178	258	524

[Our readers will better understand this table if we mention that an error of one mile is equivalent to four seconds.—Ed.]

"For the 1,700 chronometers employed, the average error for a voyage of one month is 6 miles, but the error increases with time in an increasing ratio; for three months it is not 18, but 23 miles; for six months, 56 miles; for nine months, 95 miles, and for twelve months, 136 miles. For the best fifty in one hundred the average error for one month is 1 mile, and for twelve months 36 miles; while for the worst fifty in one hundred, the average error for one month is 10 miles, and for twelve months 236 miles. The best ten in one hundred, as will be seen by the table, were almost perfect, the errors ranging from 0 to 5 miles in voyages of from one to twelve months, while for the worst ten in one hundred the errors range from 25 to 524 miles for voyages of the same length.

Table showing the daily rates gaining of six chronometers for five weeks ending Febauary 21.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6	Mean daily temp.
	s.	s.	s.	s.	s.	s.	°
19	0.5	0.6	3.4	2.8	1.3	2.5	55
20	0.6	0.7	3.5	3.1	1.1	2.9	55
21	0.9	0.5	3.6	3.0	1.0	2.9	55
22	0.9	1.0	3.5	3.1	1.3	2.5	56
23	0.5	0.9	3.5	3.1	1.4	2.2	55
24	0.6	0.8	3.6	3.0	1.1	2.3	55
Means	0.67	0.75	3.52	3.02	1.20	2.55	55

Table showing the daily rates, etc.—Continued.

Jan. 26	1.2	1.1	1.8	2.1	3.3	2.1	70
27	1.2	1.4	1.8	2.0	3.3	2.2	70
28	1.2	1.5	1.9	2.3	3.3	2.5	70
29	1.2	1.6	2.1	2.3	3.1	2.3	70
30	1.0	1.7	1.9	2.5	3.1	2.5	70
31	0.9	1.4	2.0	2.2	3.4	2.7	71
Means	1.12	1.45	1.92	2.20	3.25	2.38	70
Feb. 2	0.8	0.7	0.8	0.4	4.3	4.4	85
3	0.7	0.8	0.9	0.5	4.3	4.8	85
4	0.7	0.6	0.8	0.7	4.1	4.6	84
5	0.4	0.7	0.7	0.3	4.0	4.3	85
6	0.6	0.6	0.7	0.5	3.9	4.3	85
7	0.9	0.9	0.9	0.6	3.9	4.3	85
Means	0.68	0.72	0.80	0.48	4.08	4.45	85
Feb. 9	1.1	1.2	2.1	2.3	2.8	2.2	70
10	1.3	1.3	1.7	2.3	2.9	2.1	70
11	1.6	1.4	1.7	2.4	3.0	2.2	70
12	1.4	1.6	2.2	2.6	2.8	2.3	71
13	1.5	1.2	2.1	2.3	2.4	1.7	69
14	1.5	1.2	2.2	2.4	2.4	1.8	69
Means	1.40	1.32	2.00	2.38	2.72	2.05	70
Feb. 16	1.0	0.6	3.6	3.4	0.5	2.8	55
17	0.9	0.4	3.9	3.3	0.3	2.5	55
18	0.9	0.8	3.9	3.5	0.4	2.3	55
19	0.6	0.4	3.6	3.3	0.4	2.1	55
20	0.8	0.7	3.4	3.6	0.3	2.3	56
21	0.7	0.9	3.9	3.6	0.7	2.6	56
Means	0.82	0.63	3.72	3.45	0.43	2.43	55

"It appears that chronometers in the merchant service, when at sea, are generally exposed to temperatures ranging from about 55° to 85° of Fahrenheit, and that for most practical purposes it is sufficient for the shipmaster to know the rate in the three definite temperatures 55°, 70°, and 85°. The following examples, taken from our records, will illustrate the method I have devised to supply this information. The temperature is changed 15° on Saturday mornings. No comparisons being made on Sundays, the rate for Monday in each week is the mean of two days.

"From the preceding six examples, the following results for the middle period of the test are deduced:

Table showing the mean daily rates gaining, in three different temperatures.

Mean temperature.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
°	s.	s.	s.	s	s.	s.
55	0.75	0.69	3.62	3.24	0.82	2.49
70	1.26	1 39	1.96	2.29	2 99	2.22
85	0.68	0.72	0.80	0.48	4.08	4.45

Table showing the weekly increase of gaining-rate deduced from the first and last weeks of the test.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
s.	s.	s.	s.	s.	s.
0.04	-0.03	0.05	0.11	-0.19	-0.03

"The efficiency of the method will be seen by the following three examples, in which the test was repeated four times in succession:

Table showing the mean daily rates, gaining, of three chronometers tested in three different temperatures four times in succession.

Middle period of test.	No. 1.			No. 2.			No. 3.		
	55°	70°	85°	55°	70°	85°	55°	70°	85°
	s.	s.	s.	s.	s.	s.	s.	s.	s.
November 12..	2.4	2.2	1.1	0.7	1 6	1.5	1.5	1.4	0.8
December 10..	2.5	2.3	1.3	1.4	2.2	2.0	1.8	1.6	1.0
January 7..	2 6	2.6	1.5	1.7	2.4	2.3	1.9	1.7	1.2
February 4..	2.8	2.5	1.4	1.7	2.5	2.3	1.9	1.6	1 0

"The preceding examples have not been selected to show the large errors in a ship's longitude which might result from the use of very bad instruments, but rather that in what are considered good and carefully regulated chronometers errors may, with adequate means for testing, be detected, and tables of corrections supplied to the mariner."

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Prof. Tyndall's Lectures on Light.

FIRST LECTURE.

All men's notions of nature have some foundation in human experience. This is the broad foundation on which intellectual structures ultimately rest. The notion of personal volition in nature had this basis. In the fury and the serenity of natural phenomena the savage saw the transcript of his own varying moods, and he accordingly ascribed these phenomena to beings of like passions with himself, but vastly transcending him in power. Thus the notion of causality—the assumption that natural things did not come of themselves, but had unseen antecedents—lay at the root of even the savage's interpretation of nature. Out of this bias of the human mind to seek for the antecedents of phenomena, all science has sprung.

The first sciences were those of observation, when the matter of thought was provided by man's environment, and he had no notion of creating it himself. The apparent motion of sun and stars first drew towards them the questionings of the intellect, and accordingly astronomy was the first science developed. Slowly, and with difficulty, the notion of natural forces took root in the mind, its seeding being the actual observation of electric and magnetic attractions. Slowly, and with difficulty, the science of mechanics had to grow out of this notion; and slowly at last came the full application of mechanical principles to the motions of the heavenly bodies. We trace the progress of astronomy through Hipparchus and Ptolemy; and, after a long halt, through Copernicus, Galileo, Tycho Brahe, Kepler; while from the high table-land of thought raised by these mighty men, Newton shoots upward like a dominant peak overlooking all others from his stupendous elevation.

PRIMARY IDEAS OF LIGHT.

But other objects than the motion of the stars attracted the attention of the ancient world. Light was a familiar phenemenon, and from the earliest times we find men's minds busy with the attempt to render some account of it. But without experiment, which belongs to a later stage of scientific development, no progress could be made on this subject. The ancients, accordingly, were far less successful in dealing with light than in dealing with solar and stellar motions. Still they did make a little progress. They satisfied themselves that light moved in straight lines; they knew also that these lines or rays of light were reflected from polished surfaces, and that the angle of incidence was equal to the angle of reflection. These two results of ancient scientific curiosity constitute the starting point of our present course of lectures.

Both of these are capable of the easiest experimental illustration; but in the first place it may be useful to say a few words regarding the source of light to be employed in our experiments. The rusting of iron is, to all intents and purposes, the slow burning of iron. It develops heat, and if the heat be preserved a high temperature may be thus attained. The destruction of the first Atlantic cable was probably due to heat developed in this way. Other metals are still more combustible than iron. You may light strips of zinc in a candle flame, and cause them to burn almost like strips of paper. But beside combustion in the air, we may also have combustion in a liquid. Water, for example, contains stores of oxygen, which may unite with, and thus consume a metal immersed in it. It is from this kind of combustion that we are to derive the heat and light employed in the present course.

Their generation merits a moment's attention. Before you is an instrument—a small voltaic battery—in which zinc is immersed in a suitable liquid. Matters are so arranged that a strain is set up between the metal and the oxygen, actual union, however, being avoided. Uniting the two ends of the battery by a thick wire, the attraction is satisfied, the oxygen unites with the metal, the zinc is consumed, and heat, as usual, is the result of the combustion. A power, which, for want of a better name, we call an electric current, passes at the same time through the wire.

Cutting the thick wire in two, I unite the severed ends by a thin one. It glows with a white heat. Whence comes that heat? The question is well worthy of an answer. Suppose, in the first instance, when the thick wire was employed, that we had permitted the action to continue until 100 grains of zinc were consumed, the amount of heat generated in the battery would be capable of accurate numerical expression. Let the action now continue with this thin wire glowing until 100 grains of zinc are consumed. Would the amount of heat generated in the battery be the same as before? No, it would be less by the precise amount generated in the wire outside the battery. In fact, by adding the internal heat to the external, we obtain for the combustion of 100 grains of zinc a total which never varies. By this arrangement, then, we are able to burn our zinc at one place, and to exhibit the heat and light of its combustion at a distant place. In New York, for example, we have our grate and fuel; but the heat and light of our fire may be made to appear at San Francisco. We have here an illustration of the constant law that in physical nature we have incessant substitution, but never creation.

I now remove the thin wire and attach to the severed ends of the thick one two thin rods of coke. On bringing the rods together we obtain a small star of light. Now the light to be employed in our lectures is a simple exaggeration of this star. Instead of being produced by 10 cells, it is produced by 50. Placed in a suitable camera, provided with a suitable lens, this light will give us all the beams necessary for our experiments.

DEFECTS OF THE EYE.

And here, in passing, let me refer to the common delusion that the works of nature, the human eye included, are theoretically perfect. The degree of perfection of any organ is determined by what it has to do. Looking at the dazzling light from our large battery you see a globe of light, but entirely fail to see the shape of the coke-points whence the light issues. The cause may be thus illustrated: On the screen before you is now projected an image of the carbon points, the whole of the lens in front of the camera being employed to form the image.

It is not sharp, but surrounded by a halo which nearly obliterates it. This is due to an imperfection of the lens, called spherical aberration, due to the fact that the circumferential and central rays have not the same focus. The human eye labors under a similar defect, and when you looked at the naked light from 50 cells the blur of light upon the retina was sufficient to destroy the definition of the retinal image of the carbons. A long list of indictments might indeed be brought against the eye—its opacity, its want of symmetry, its lack of achromatism, its absolute blindness in part. All these taken together caused an eminent German philosopher to say that if any optician sent him an instrument so full of defects he would send it back to him with the severest censure. But the eye is not to be judged from the stand-point of theory. As a practical instrument, and taking the adjustment by which its defects are neutralized into account, it must ever remain a marvel to the reflecting mind.

And now we are ready for work. The rectilineal propagation of light may be beautifully illustrated by making a small hole in a window-shutter before which stands a house or tree, or animal, and placing within the darkened room a white screen at some distance from the orifice. Every straight ray proceeding from the object stamps its color upon the screen, and the sum of all the rays forms an image of the object. But as the rays cross each other at the orifice the image is inverted. An image of the carbon points produced by a pinhole in tinfoil will be employed to illustrate this point of rectilineal propagation.

SLOW PROGRESS OF OPTICS.

The law that the angle of incidence is equal to the angle of reflection is illustrated in this simple way: A straight lath is placed as an index perpendicular to a small looking-glass capable of rotation. A beam of light is received upon the glass and reflected back along the line of its incidence. Though the incident and the reflected beams pass in opposite directions, they do not jostle or displace each other. The index is now turned, the mirror turns along with it, and at each side of the index the incident and the reflected beams are seen tracking themselves through the dust of the room. The mere inspection of the two angles inclosed between the index and the two beams shows their equality. The same simple apparatus enables us to illustrate a law of great practical importance, namely, that when a mirror rotates, the angular velocity of a beam reflected from it is twice that of the reflecting mirror.

For more than 1,000 years no step was taken in optics beyond this law of reflection. The men of the Middle Ages, in fact, occupied themselves on the one hand in trying to develop the laws of the universe out of their own consciousness, while on the other hand they were so occupied with the concerns of a future world that they looked with a lofty scorn on all things pertaining to this only. As regards the refraction of light, the course of real inquiry was resumed in 1100 by an Arabian philosopher named Alhazen. Then it was taken up in succession by Roger Bacon, Vitellio, and Kepler. One of the most important occupations of science is the determination by precise measurements of the quantitative relations of phenomena. The value of such measurements depends upon the skill and absolute conscientiousness of the man who makes them. Vitellio was such a man, while Kepler's habit was to rummage through the observations of his predecessors, look at them in all lights, and thus distill from them the principle which united them. He had done this with the astronomical measurements of Tycho Brahe, and had extracted from them the celebrated "laws of Kepler." But in the case of refraction he was not successful. The principle, though a simple one, escaped him. It was first discovered by Willebord Snell, about the year 1621.

Less with the view of dwelling upon the phenomena itself, than of introducing it to you in a form which will render intelligible the play of theoretic thought in Newton's mind, I will show you the fact of refraction. The dust of the air and the turbidity of a liquid may here be turned to account. A shallow circular vessel with a glass face, half filled with water, rendered barely turbid by the precipitation of a little mastic, is placed upon its edge with its glass face vertical. Through a slit in the hoop surrounding the vessel, a beam of light is admitted. It impinges upon the water, enters it and tracks itself through the liquid in a sharp, bright band. Meanwhile the beam passes unseen

through the air above the water. A puff of tobacco smoke into this space at once reveals the track of the incident beam. If the incidence be vertical, the beam is unrefracted. If oblique, its refraction of the common surface of air and water is rendered clearly visible. It is also seen that reflection accompanies refraction, the beam dividing itself at the point of incidence into a refracted and a reflected portion.

DISCOVERIES OF SNELL AND DESCARTES.

Snell connected the angle of incidence with the angle of refraction, by proving that the sine of the one divided by the sine of the other is absolutely constant for the same medium, whatever the obliquity of the incident ray may be. The lines answering to these "sines" will be pointed out in the lecture. The constant quotient here referred to is called the index of refraction. The discovery is one of the corner stones of optical science.

Quickly following Snell's discovery, is the application of it by Descartes to the explanation of the rainbow. The bow is seen when the back is turned toward the sun. Draw a straight line through the spectator's eye and the sun, the bow is always seen at the same angular distance from this line. This was the great difficulty. Why should the bow be always and at all parts 41° distant from this line? Taking a pen and calculating the track of every ray through a rain-drop, Descartes found that at one particular angle the rays emerged from the drop almost parallel to each other, being thus enabled to preserve their intensity through long atmospheric distance; at all other angles the rays quitted the drop divergent, and through this divergence became practically lost to the eye. The particular angle here referred to was the foregoing angle of 41°, which observation had proved to be invariably that of the rainbow.

But in the rainbow a new phenomenon was introduced—the phenomenon of color. And here we arrive at one of those points in the history of science when men's thoughts and labors so intermingle that it is difficult to assign to each worker his precise meed of honor. Descartes was at the threshold of the discovery of the composition of solar light. But he failed to attain perfect clearness, and it is certain that he did not enunciate the true law. This was reserved for Newton, who went to work in this way.

Through the closed window-shutter of a room he pierced an orifice, and allowed a thin sunbeam to pass through it. The beam stamped a round image of the sun on the opposite white wall of the room. In the path of this beam Newton placed a prism, expecting to see the beam reflected, but also expecting to see the image of the sun, after refraction, round. To his astonishment it was drawn out to an image whose length was five times its breadth; and this image was divided into bands of different colors. Newton saw immediately that this image was due to the fact that some constituents of the solar light were more deflected by the prism than others, and he concluded, therefore, that white solar light was a mixture of lights of different colors and of different degrees of refrangibility.

The elongated image here referred to is called the spectrum. Newton divided the spectrum into seven parts—red, orange, yellow, green, blue, indigo, violet—which are commonly called the seven primary or prismatic colors.

NEWTON'S DOUBLE METHOD OF PROOF.

This was the first analysis of solar light by Newton; but the scientific mind is fond of verification, and never neglects it where it is possible. It is this stern conscientiousness on the part of those who pursue it that gives adamantine strength to science, and renders all assaults on it unavailing. Newton completed his proof by synthesis. For instance, he refracted the colors back, reblended them, and thus reproduced the white light out of which they came.

In the lecture, Newton's experiment in Newton's own form is made; it is afterward made with instruments which yield larger and richer effects than those seen by Newton. The synthesis of white light is effected in three different ways. Firstly, the colors of the spectrum are squeezed together and blended by a cylindrical lens, white light being the result of their mixture; secondly, an image of the carbon points, whence the light issues, is built up from the colors of the spectrum; thirdly, in virtue of the persistence of luminous impressions upon the retina, the prismatic colors may be mixed together in the eye itself, the impres-

sion of whiteness being the result. The drawing out of the white light into a spectrum is called dispersion. And here historic completeness renders necessary a brief reference to an error of Newton's. He supposed that refraction and dispersion went hand in hand, and that if you abolished the one you at the same time abolished the other. He maintained this opinion to the end of his life, and thus retarded the progress of Discovery. Dolland, however, proved that by combining two different kinds of glass the colors could be extinguished, still leaving a residue of refraction, and he employed this residue in the construction of achromatic lenses—lenses which yield no color—which Newton thought an impossibility. This point is illustrated in the lecture by combining a prism of water and one of glass; the color is destroyed, but not the refraction.

The refraction and dispersion of bisulphide of carbon are compared with those of water, in order to explain why the first mentioned liquid is used when our object is to obtain spectra of great extent and richness of color.

PHENOMENA DUE TO WHITE LIGHT.

Having unravelled the interwoven constituents of white light, we have next to inquire what part the constitution so revealed enables this agent to play in nature. To it we owe all the phenomena of color; and yet not to it alone, for there must be a certain relationship between the ultimate particles of natural bodies and light to enable them to extract from it the luxuries of color. But the function of natural bodies is here selective, not creative. There is no color generated by any natural body in any kind of form. Natural bodies have showered upon them, in the white light of the sun, the sum total of all possible colors, and their action is limited to the sifting and appropriating from the total the colors which really belong to them, and rejecting those which do not. It will fix this subject in your minds if I say that it is the portion of light which they reject, and not that which belongs to them, that gives bodies their colors.

Let us begin our experimental inquiries here by asking what is the meaning of blackness? Pass a black ribbon in succession through the colors of the spectrum; it quenches all. This is the meaning of blackness—it is the result of the absorption of all the constituents of solar light. Pass a red ribbon through the spectrum. In the red light the ribbon is a vivid red. Why? Because the light that enters the ribbon is not quenched or absorbed, but sent back to the eye. Place the same ribbon in the green or blue of the spectrum; it is black as jet. It absorbs the green and blue light, and leaves the space on which they fall a space of intense darkness. Place a green ribbon in the green of the spectrum. It shines vividly with its proper color; transfer it to the red, it is black as jet. Here it absorbs all the light that falls upon it, and offers mere darkness to the eye. When white light is employed, the red sifts it by quenching the green, and the green sifts it by quenching the red, both exhibiting the residual color. Thus the process through which natural bodies acquire their colors is a negative one. These colors are caused by subtraction, not by addition The action of various liquids and solids upon the spectrum is also illustrated; some cutting off the one end, others cutting off the other end, and some selecting for absorption the middle of the spectrum.

COMPLEMENTARY COLORS AND ABSORPTION.

These experiments prepare us for the consideration of a point regarding which error has found currency for ages. You will find it stated in books that blue and yellow lights mixed together produce green. They do not. Blue and yellow are complementary colors, and produce white by their mixture. The mixture of blue and yellow pigments undoubtedly produces green, but the mixture of pigments is totally different from the mixture of lights. Helmholtz has revealed the cause of the green in the case of the pigments. No natural color is pure. A blue liquid or a blue powder permits not only the blue to pass through it, but a portion of the adjacent green. A yellow powder is transparent not only to the yellow light, but also in part transparent to the adjacent green. Now, when blue and yellow are mixed together the blue cuts off the yellow, the orange, and the red; the yellow, on the other hand, cuts off the violet, the indigo, and the blue. Green is the only color to which both are transparent, and the consequence is that when white light falls upon a mixture of yellow and blue powders, the green alone is sent back to the eye.

The explanation of the mixture of pigments will be subjected to the test of experiment; and in a subsequent lecture the mixture of colored lights will be employed to prove that blue and yellow, by their blending, produce white. This question of absorption is one of the most subtle and difficult in molecular physics. We are not yet in a condition to grapple with it, but we shall be by and by.

Meanwhile we may probably glance back on the web of relations which these experiments reveal to us. We have, in the first place, in solar light an agent of exceeding complexity, composed of innumerable constituents refrangible in different degrees. We find, secondly, the atoms and molecules of bodies gifted with the power of sifting solar light in the most various ways, and producing, by this sifting, the colors observed in nature and art. To do this they must possess a molecular structure commensurate in complexity with that of light itself. Thirdly, we have the human eye and brain so organized as to be able to take in and distinguish the multitude of impressions thus generated. Thus the light at starting is complex; to sift and select it as they do natural bodies, must be complex. Finally, to take in the impressions thus generated, the human eye and brain must be highly complex. If we were permitted to inquire into the intention of Nature, we might well ask whence this triple complexity? If what are called material purposes were the sole end of Nature, a much simpler mechanism would be sufficient. But instead of simplicity—instead of principle of parsimony—we have prodigality of relation and adaptation, and this apparently for the sole purpose of enabling us to see things robed in the splendors of color. Would it not seem that Nature harbored the intention of educating us for other enjoyments than those derivable from meat and drink? At all events, whatever Nature meant—and it would be mere presumption to dogmatize as to what she meant—we find ourselves here, as the issue and upshot of her operations, endowed with capacities to enjoy not only the materially useful, but endowed with others of indefinite scope and application, which deal alone with the beautiful and the true.

[We shall give others of these lectures, from time to time, as space will permit.]

Friction.

Ed. Horological Journal:

This subject has been so *in*effectually treated, and yet so effectually *worn*, as to leave the question still so open, unsettled and unsatisfactory, that I feel impelled to add my mite, after much hesitation, with the hope that some pen more able than mine would anticipate me. I propose to treat on some important points touching this question, which have hitherto been entirely ignored or overlooked by your numerous correspondents, and to present the subject, probably, to many of your readers, in an entirely new light.

First, then, I will assume that the subject, on the basis of the staff pivots and holes, has been fully treated and experimented upon, if not to the satisfaction of the craft, yet sufficient to satisfy the experimenters that they have failed to attain their end; that the friction is still there; that the loss of motion is the same.

Next, I propose to show how, with the usual staff pivots and jewel holes, properly made (shaped), fitted, and polished, a superior motion can be given to the balance with scarcely any perceptible variation in change of position. But to do this requires particular attention to certain points named below.

It is surprising how few watchmakers of the present day fully understand the principles of the lever escapement. If asked the question, "Do you understand the principles of the lever escapement?" the reply is "Oh, yes!" But when asked to explain it, nine out of ten will be lost in a fog. They will tell you that such and such pieces must be so and so, but why this is thus, or whether right or wrong, they cannot tell, and the "Master" is responsible.

I will now proceed to give a few general directions for putting a watch "in order," taking, for example, an English lever, the same remarks applying to the American lever, minus the fusee. I not unfrequently find a mainspring several grades too strong (evidently put in to give the watch a motion), and when I have put the watch in order, have had to substitute a spring of proper strength, else subject the watch to too much motion, resulting in undue friction and wear of the parts. In examining a watch for repairs, I begin with the staff, and thence down; but it is immaterial where

one begins, so that all the necessary repairs are ascertained, as far as possible, before taking the watch down; I begin with the main spring, because that is the power, and the root of many evils when not correct. It should be of the right width and thickness. If too wide, friction, by too close contact with barrel cover and bottom, results; consequently, loss of power. If too narrow, and of sufficient strength and length, the barrel will be too full, and may not allow turns enough for the scope of the fusee, causing irregularity of power, and also of time, by the spring not being properly guided by its barrel. I will mention that many watchmakers seem to think it unnecessary to clean a main-spring or the inside of a barrel, and are seldom guilty of taking off a barrel cover unless compelled to. The main-spring should be as clean and as free from friction as any other part of the movement. See that the barrel is not spread by the breaking of the chain or main-spring; if so, it should be restored, and the cover turned true to fit, and the barrel trued. This is too often the case with English watches, the barrels being too light.

The universal lathe is a very useful tool, but it is too often misused by many who ought to know better, by turning out the plates for freeing the barrel, fusee, etc., when the right way for truing up and correcting side shakes, etc., is generally quite as easy and much more satisfactory. For the "modus operandi," I will refer the reader to the eminently practical articles, published in your Journal, from the pen of our friend and brother, James Fricker, of Americus, Ga., and suggest a careful perusal. To insure freedom from all undue friction, and consequently loss of power, all the pinions and arbors should be mathematically upright; and the end and side shakes correct.

Bad "pitching" is another source of trouble. Reid says: "If a wheel drives a pinion which is too large, or (which is the same) whose leaves or teeth are more distant from one another than those of the wheel, the force communicated by the wheel will in part be destroyed by the leaves of the pinion which butt against the wheel teeth; and this force, so destroyed, will require that a greater motive force be used to keep up the motion; from which will result friction, wearing, variations, etc." * * * "If a wheel drives a pinion which is too small, or whose teeth are less distant than those of the wheel, it will happen that a tooth of the wheel acting on a lever or tooth too short, the pinion will turn with less force, etc." Thus, as will be observed, isochronism is destroyed, the parts come to undue wear, and the watch is valueless as a timekeeper. Bad depthing, which is sometimes occasioned by the holes or pivots wearing out of true, causes similar results.

The source of one of the most fruitful evils as regards friction, which requires the greatest care and accuracy of adjustment, and which is more frequently overlooked or misunderstood, is the escapement. First. The end and side shake of the escape wheel and pallet arbor should be just sufficient for freedom of action, because the parts, being smaller, are more susceptible to the slightest deviation from truth. Second. See that the pallets are "in angle," that is, that the slide of the tooth is equal on the detent surface of each pallet, and just deep enough to make a good lock. If too deep, with the bankings properly adjusted, the roller is too large; result, undue friction and loss of motion. If too shallow, with the guard pin against the roller, the roller is too small; result, imperfect locking of scape wheel tooth on pallet, and the watch stops by reason of the tooth reaching the impulse face of the pallet and forcing the guard pin against the roller. Third. See that the guard pin is upright and free from the corners of the crescent of the roller at each vibration; also, that the roller is round, or true in periphery; otherwise, the result will be the same as when the roller is too large or too small. Fourth. The ruby pin must be just large enough to work free in the slot of the fork, and be firm in the roller.

Supposing all the above parts to have been properly adjusted, as also the balance staff, we come to the hairspring, one of the most vital points to be considered in a machine for producing perfect time. The hairspring should be as true as possible, both in the flat and the round, so that at any and all stages of the vibrations of the balance the coils may be nearly equidistant from each other, and bearing equally on either regulator pin at each vibration. Too much importance cannot be attached to this part of the watch.

I have thus alluded in brief to what I consider the more fruitful causes of friction, causing loss of power and poor motion in watches, without going into detail as to how the remedy is to be applied, leaving that to the skill and good sense of my brother workmen. I am glad to see such skilful and practical articles on this subject as those from the pen of Mr. James Fricker, which deserve special attention from the craft; and if his directions are followed, they will find themselves benefited as well as the watches.

S. S. Barnaby.

Marion, Ala.

A Few of the Little Details.

Ed. Horological Journal:

There is quite a common practice among watchmakers, after taking down Swiss watches to be put in order, to clean the balance with its bridge, oiling the hole and putting the hairspring stud in its place, leaving them together under the glass until all of the other pieces are cleaned and the watch put together. I always take out the balance with its bridge and separate them the first thing I do, and leave them apart until the watch is all together ready for the balance, when I clean the bridge and balance, oil the hole, put the hairspring stud in place, and put them in their places.

It is very plain to be seen that the top pivot of the balance staff is much safer when the balance is laying loosely on the bench or under the glass, than it is when resting in the hole jewel of the bridge with the other end free and ready to act as a lever if anything should happen to hit it, and thus break off or bend the other pivot.

The same result would be obtained under the glass, if the glass should happen to get shoved sideways against the balance. These risks are unnecessary, and I consider it quite important to run as little risk with the balance and staff as possible, for these parts are very sensitive, and the slightest bending of a balance pivot will invariably spoil the watch for good time.

When putting a fusee watch together it is well to leave the lever out at first, pulling the plate down and pinning in place; then put on the chain and wind all up on the fusee, observing whether the stop-piece works all right, and also that when running down, the chain does not run above or against the hook on the barrel, the key of course remaining on the fusee square with the hand, holding back a little so as to let it run down quite slowly and not bring so much strain on the pivots of the train. After the chain has all run out, the three pins may be taken out and the plate gently lifted, the lever put in its place with the tweezers, and the pivots all may be put in their places when the watch is ready for the balance.

Much time and trouble may be saved in this way, for it is quite often that a watch has to be all taken down again, and these adjustments made after it has performed badly, and the owner been dissatisfied. In a full plate movement with going barrel, it is well to leave out the lever at first, putting the train pivots in their places, pressing the top plate down, and giving the barrel a little power, to see if the train runs freely. If there should be anything wrong one is quite likely to see it at once, and it takes only a moment longer. Besides, it is quite necessary that the watch should be wound a little before the lever is in, that the barrel may run entirely around, and one can see whether it is true in its place and does not touch the centre wheel or its own bridge.

F. G. C.

Boston, Mass.

Oil on Main-Springs.

Ed. Horological Journal:

I notice in a late number of the Journal that one of your correspondents, J. P. W., of Bradford, Ont., has had some trouble with the breaking of main-springs, and charges it to Kelley's oil. My attention was called in the same direction some few years ago on account of having the same trouble with the breaking of springs that J. P. W. seems to have had, and I paid particular attention to the oil, as well as to some other causes, and which I made mention of in an article to the *Scientific American*, of November 19th, 1870, on the breaking of the main-springs. My experience has been that the oil is undoubtedly the cause of many breakages, but not one oil any more

than another. Doubtless, many of the trade have taken in a watch to be cleaned, and on examination found nothing more wanting; the watch is then taken down, and every part carefully cleaned, excepting the main-spring, which seems to be clean, but would need a little oil, and thinking it not necessary to take the spring out it is oiled in the barrel; now the watch is carefully put together and set to running, but probably in a few days, or perhaps in a few hours, the workman finds the spring is broken.

Now what caused it to break? Was it not the oil? It may be said that if the spring was taken out, cleaned, oiled and put back, it would not be so liable to break; but I find it to be the reverse, especially if you have no other means of placing it back but those generally used. I merely give this as my experience on an old spring, as it might be charged to a new one as being of too high and uneven temper, which is sometimes the case, especially with the low grade of springs. Again, I always had noticed after oiling a spring and winding it up to the last turn or two, when the coils pressed closer together, that I could feel a gritty sliding of the coils on each other. This I did not pay much attention to until I constructed my new main-spring winder, by which I discovered this gritty sliding was caused by the oil, not so much with clock oil as with watch oil, and not near so much with sewing machine oil, and not at all perceptible without either; therefore I hold that the watch or clock oil, so far as watch springs are concerned, will increase friction, and thereby cause fracture. No doubt many of the trade will think this idea erroneous, but before drawing their conclusions let them investigate the matter for themselves. I have adopted the following plan, viz., never to oil an old spring in the barrel, and when it's absolutely necessary to take it out, I handle it as little as possible, and before placing it back, oil it with a rag saturated with clock oil, and then run to the centre and back a clean piece of tissue paper, free from dust, which leaves no oil but enough to keep off moisture; I then coil it snugly on my winder and place it in the barrel. I treat a new one the same, and the result is satisfactory.

M. D. Kelly.

Cadiz, Ky.

The New Lathe.

Ed. Horological Journal:

We are very much obliged to you for the privilege of answering the numerous inquiries we are having about our lathes and for descriptive catalogues. We have no circular out yet, but will give a brief description of some points on the lathes which were not given in the Journal; also, fixtures, etc.

The No. 2 lathe has a screw tail stock; also an index of 120 holes on the cone. They can be furnished with No. 1 lathe if desired. All fixtures, such as universal heads, slide, jewelling and swing rests, grinding fixtures, extra head and tail stocks, wheel and pinion, cutting fixtures, etc., are furnished separately from the lathes. They are all planed to standards, and are interchangeable. The head and tail stocks, universal heads, jewelling and swing rests, are planed, so as to "line" perfectly. This obviates the necessity of sending the lathes to us to be fitted every time there is an extra fixture needed, and also the inconvenience (in a great many cases) of purchasing a lathe and its fixtures at the same time.

The lower slide of the slide rest is at right angles with the lathe bed, and the circular base of the upper slide is graduated into 360°. This slide, which has upon it the tool or cutter carrier, can be set at any angle without changing the position of the lower or cross slide. By having the cross slide arranged in this way it forms a very firm base for the rest. Lathe beds can be made longer than the regular sizes if desired. For lengths, see advertisement. There is a counter shaft with each lathe, and the lathes are all nickel-plated.

Those ordering lathes, and wishing their chucks any particular sizes, should state distinctly what they need. The measurements may be given by the French metric measure, United States standard measure, or by Stubb's wire gauge. An additional price will be charged for hardened chucks.

The step chucks can be graduated by having a number of chucks, and having the steps in all the chucks the same length—say five steps in a chuck; multiply the number of steps in one chuck by the number of chucks desired, and there will be as many different sizes. The more chucks there are the finer will be the

graduations. Extra chucks can be furnished if desired.

The grinding fixture has a swing similar to the jewelling rest, and has a traverse spindle which carries the laps, and near the front bearing is a small pillar with a screw for adjusting the swing. The rest is held in the same manner as the T rest, and can be set at any angle.

BALLOU, WHITCOMB & Co.,
18 *Harvard Place, Boston, Mass.*

—o—

Answers to Correspondents.

J. P. S., *Atalanta, Ga.*—The square cut at the top of the *p. d. t.*, etc., are produced by a separate cut, the point of the graver being set in just sufficient to square the top of the cut nicely.

K. O., *Maryland.*—To make the heads of long screws flat, you need a good screw head tool which any tool dealer will sell you. The polishing disk, which is a part of it, has two or three segments of metal for grinding and polishing the head flat. While the screw is revolved by one hand, the polishing (or grinding) disk is oscillated, or "wig-waged" back and forth by the other, so that the abrading material shall not grind circles upon the screw head. Upon your lathe it is impossible to produce a perfectly flat head without some appliance by which a flat surface can be oscillated across the head in a place that remains constant at right angles to the axis of the screw.

M. B. F., *Virginia.*—If you had given the subject a little thought, you would not have encountered the difficulty you mention. It is easy enough to get measurements when one part of a pinion is "buried out of reach in the cement on the lathe." To illustrate, which will be the easiest way to explain: Suppose you wish to put a new centre pinion in a detached lever; the pinions, as bought, are not finished—cannot be—because the length between shoulders is not known, consequently both ends must be finished up to order. First, chuck the pinion in the lathe, with the end exposed which is to be pivoted, and the lever faced to a finish, which may be done by measurement from the old one, which you are supposed to have. After that is done, the trouble you experienced begins; you wish to reverse it in the wax, and then finish up the other end, with the proper distance between the shoulders. Before chucking the second time, measure the distance from shoulder to shoulder of the old pinion, which we will assume to be 14° of the Swiss gauge; now measure upon the half-formed new one, the distance from the finished shoulder to the extreme of the unfinished end, which will be perhaps 22.5°; set these measurements down, that no mistake may be made through treachery of the memory; now chuck the new pinion, and proceed to finish up the pivot by measurement from the *outer* exposed extreme end; from the shoulder within the wax to this outer end you know to be 22.5°, the length required between shoulders is 14°, which, deducted from the extreme length, leaves 7.5°, as the distance from the outer end to the shoulder, which distance is easily measured by your gauge. The amount to be cut away from the leaves to form the seat for the web of the wheel can be found by inspection, or by measurement from the shoulder just found and formed. By working thus to actual measurement, you have the positive assurance that when completed it will fit at once, thus saving all the time unnecessarily lost by the cut and try method of working, and saving yourself the anxiety which is an inevitable attendant upon uncertainties.

G. T., *Illinois.*—Some pains have been taken to answer in full the questions you ask, but you must be patient a little longer. The manufacture of watch hands is mostly carried on abroad; still there is quite a business in the manufacture for American watches in this country; one concern using about half a ton of steel wire for that purpose in one year. The American hands are all steel, socket and all, the holes through them being drilled at the rate of 18 per minute in a machine which works automatically.

J. D. S., *Oregon, Mo.*—Extreme cold, of itself, will not stop your regulator except through the influence it exerts in changing the condition of the oil. You say that you have oiled it with Kelley's oil, which is first class, and you also state that it has not frozen in the room this winter. From these two circumstances we would judge that the extreme cold weather outside has nothing whatever to do with your regulator stopping. There must be something defective about it which would cause

it to stop in any kind of weather. Is the pendulum spring not twisted a little, and does the back fork or guide fit the pendulum free, but without shake, and is it perfectly square? If any of these points be defective the regulator will be very liable to stop; but if they be in good order, the cause of the clock stopping must either lie in the escapement or in the train.

E. N., *Goshen, Conn.*—We consider that the Baroness Burdett Coutts' prize essays on the balance spring are, so far as we can judge from those which have been published, a partial failure. None of the writers treat the subject in the broad comprehensive manner we consider it ought to be treated. They write as if they were only addressing their brethren in Clerkenwell, who are employed springing watches and chronometers, instead of the watchmakers of the whole world, whom in reality they are addressing. There is a great lack of completeness in these essays, and a want of clearness in some of the language employed; but it is to be hoped that those two essays which have been awarded the prize will be more clear and comprehensive.

The obscure passages in the essay you speak of evidently refer to coiling up the spare pieces at the ends of the spring so that they will be out of the way, and the pins which you mention are doubtless intended by the writer to be placed in the rim of the balance.

K. G., *Missouri.*—Certainly it would be desirable to dispense with a counter-shaft to the bench lathe, if the same results could be produced without it, for the money it costs, and the space it occupies, could then be used for other purposes.

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AT $1.50 PER YEAR, PAYABLE IN ADVANCE.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For March, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be added to Apparent Time.	Diff. for One Hour.
		s.	M. S.	s.
Saturday	1	65.40	12 30.20	0.499
Sunday	2	65.33	12 17.96	0.521
Monday	3	65.26	12 5.20	0.541
Tuesday	4	65.19	11 51 96	0.560
Wednesday	5	65.13	11 38.27	0.579
Thursday	6	65.07	11 24.14	0.597
Friday	7	65.01	11 9.56	0.615
Saturday	8	64.95	10 54 59	0.631
Sunday	9	64.90	10 39.23	0.647
Monday	10	64.85	10 23.52	0.662
Tuesday	11	64.80	10 7.46	0.676
Wednesday	12	64.76	9 51.09	0.689
Thursday	13	64.72	9 34.43	0.701
Friday	14	64.68	9 17 50	0 711
Saturday	15	64 65	9 0.32	0.721
Sunday	16	64.62	8 42.90	0.730
Monday	17	64.59	8 25.32	0.738
Tuesday	18	64.56	8 7.56	0.744
Wednesday	19	64.54	7 49.64	0.750
Thursday	20	64.52	7 31.59	0.754
Friday	21	64.50	7 13.43	0.758
Saturday	22	64.49	6 55.19	0.762
Sunday	23	64.48	6 36.89	0 764
Monday	24	64.47	6 18.53	0 766
Tuesday	25	64.46	6 0.13	0.767
Wednesday	26	64.46	5 41.72	0 767
Thursday	27	64.46	5 23.32	0.766
Friday	28	64.46	5 4.94	0 765
Saturday	29	64.47	4 46.60	0.764
Sunday	30	64.48	4 28.30	0.761
Monday	31	64.49	4 10.07	0.758

Mean time of the Semidiameter passing may be found by subtracting 0s.18. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	5 13 25.0
☺	Full Moon	13 17 44.7
☾	Last Quarter	21 10 19.9
●	New Moon	28 0 54.6
		D. H.
☾	Apogee	10 20.7
☾	Perigee	26 10.6

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1
	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
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Venus	1 1 37 43.33	+12 57 21.3	3 0.3
Jupiter	1 9 49 27.04	+14 26 26.7	11 9.9
Saturn	1 20 4 6.09	− 20 30 1.8	21 23.5

AMERICAN

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CONTENTS.

ESSAY

ON

WATCHMAKERS' REGULATORS, WITH PRACTICAL DETAILS FOR THEIR CONSTRUCTION.

BY HENRY J. N. SMITH.

CHAPTER II.

THE ESCAPEMENT.

It must be admitted that the escapement of a regulator is a most vital part of its construction, yet its importance is in some instances very much overrated and its true functions are either imperfectly understood, or they are altogether lost sight of by many who seek to improve escapements. There is no special property that can be imparted to any form of escapement which will of itself produce good time-keeping, any more than any special arrangement of the wheel-work can create power. Badly arranged wheel-work will destroy power, but the best arranged train it is possible to construct will not create more power than the weight or the spring puts into it. In like manner, a badly constructed escapement will be sure to produce irregular time, but the most accurate escapement will not impart any better time-keeping qualities to the regulator than the accuracy of the construction of the pendulum will admit of. It is the pendulum, and the pendulum alone, which we must rely upon as a means of measuring time accurately.

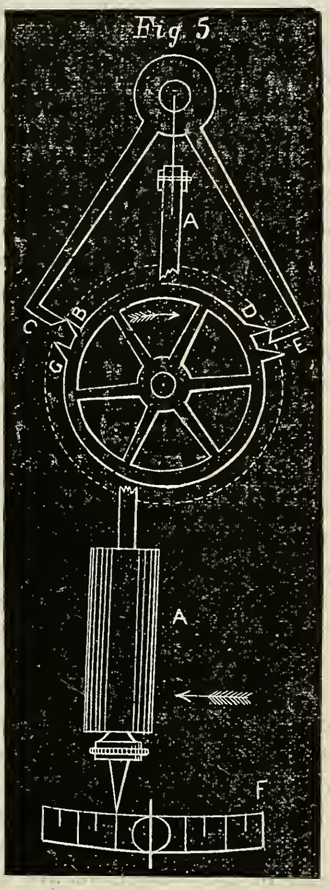
In former years the efforts of several eminent clockmakers were directed towards constructing an escapement, or making the Graham one in such a manner that it would not only maintain the vibration of the pendulum, but would also cause it to swing in a cycloidal curve, with the idea of causing its long and short vibrations to be performed in the same length of time; but in practice this has been found to be altogether impracticable. If any one will be at the trouble to draw a cycloidal curve, and a true circle of the same radius, they will observe that for several degrees on each side of the centre of the cycloidal curve there is but very little difference between it and the true circle. On page 117 of the second volume of the Journal there are two curved lines, one a true circle, the other a cycloid. These lines were made with the greatest amount of care, and every precaution was used to make them as perfect as possible; yet for a considerable distance there is no visible difference between them. In reality there is a difference, but for three or four degrees it is so small that the variation cannot be detected by the eye. From this we can imagine how extremely difficult and how uncertain it would be to correct so small an error by any mechanical contrivance. The chances are greatly in favor of larger errors being produced than those supposed to be corrected, and all attempts to cause a pendulum to describe a cycloid through the agency of the escapement are now abandoned; although attempts are still made to obtain this object through the agency of the pendulum spring, which will be noticed when we reach that part of our subject.

The only duties the escapement has to perform is simply to transmit a uniform force at regular intervals sufficient to maintain the vibrations of the pendulum, and at the same time present as few mechanical obstacles to its free vibration as possible. As different forms of escapements require a different arrangement of the wheel-work, perhaps it would be advisable,

at this stage, to make a few remarks on the subject of escapements in general, and examine into the accuracy with which the various forms recommended for regulators perform the duties required of them.

GRAHAM ESCAPEMENT.

Figure 5 represents the action of the well-known Graham, or dead-beat, escapement. The pendulum, A, has passed the perpendicular line and ascended about one degree on its upward



course. The scape-wheel tooth, B, has been released from the pallet, C, and the tooth, D, on the opposite side of the wheel, has dropped on the pallet, E, and will slide up the circular part of the pallet, E, till the pendulum has reached the end of its vibration. When the pendulum returns, the tooth will slide backward till it reaches the corner of the incline plane, and then the force of the scape-wheel pressing on the incline plane will give the necessary amount of impulse to the pendulum, and send it in the direction of F, when the tooth, G, and the pallet, C, will act in the same manner as the tooth and pallet on the opposite side of the wheel is described as having done. Were it not for the friction caused by the pallets rubbing on the teeth during the entire arc of the vibrations of the pendulum, this would be a most perfect escapement, because the pendulum receives its impulse on its downward course as it approaches the perpendicular line, which is the point mathematicians demonstrate as the best point in the whole arc of its vibration where a pendulum can receive its impulse. But, however perfect in theory this escapement may be, in practice it is considerably affected by the unavoidable friction consequent on its action ; and to make matters worse, this friction is very liable to vary as the clock becomes dirty, or the oil on the pivots gets thick or dries up. If the teeth of the scape-wheel from any of the above causes press with a varying force on the pallets, the pendulum will meet with a greater or less resistance by the pallets rubbing on the scape-wheel teeth, and the impulse given to the pendulum by the teeth pressing against the incline plane of the pallets will also vary in a like proportion from the same case. Such are the practical difficulties connected with the action of the Graham escapement.

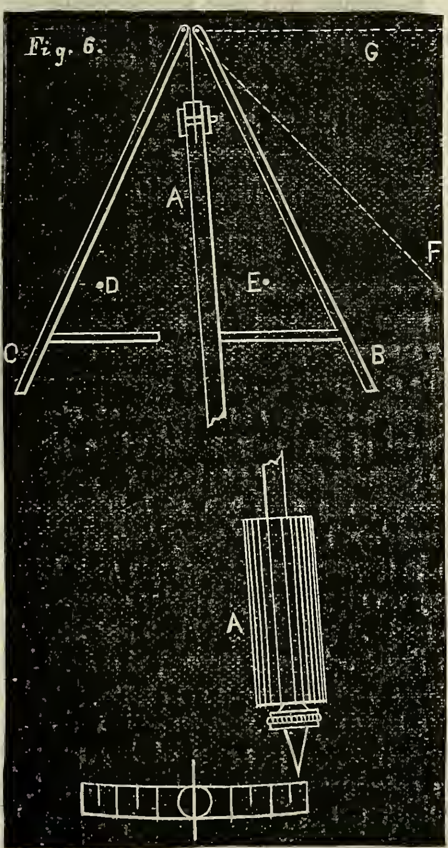
REMONTOIRS.

To obviate the above-mentioned difficulties, innumerable plans have been proposed, and many have been put into practice with a greater or less degree of success. All the different arrangements may be classed under two heads, namely, gravity escapements and remontoirs, or rewinders. It is, perhaps, unnecessary to go into the various details of remontoirs at the present time, because they are by no means likely to improve the regular performance of watchmakers' regulators, which is the subject of this essay; but it may not be out of place to mention that the general principle of all remontoirs is to use a very weak spring, or a small weight to give motion to the scape-wheel, while the large weight of the clock is employed simply to wind up this weak spring or small weight at stated intervals, and sometimes electricity has also been used for this purpose. A remontoir may be used in a clock with a Graham escapement, or it may be used in conjunction with other forms of escapements, and the errors

which it seeks to correct are those incident to the uniform transmission of the force from the weight to the scape-wheel. If this could be accomplished without creating greater errors, or adding materially to the complexity of the clock, a very important point would be gained; but from practical observation, and so far as I have had opportunities of learning, I do not know a single instance of a clock or a modern chronometer whose rate has been improved by the action of a remontoir; and as they add considerably to the complexity of the clock, and show no improved practical results in return, I consider it unnecessary to add more on the subject at present.

GRAVITY ESCAPEMENTS.

Fig. 6 is intended to represent the method by which the vibrations of a pendulum are maintained by the action of gravity escapements,



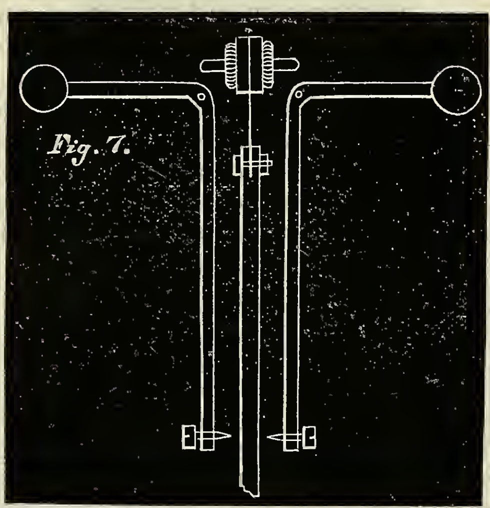
and it also illustrates the opposition this form of escapement presents to the free vibrations of a pendulum. The scape-wheel is omitted in the diagram, because its presence is unnecessary to illustrate the point in view. The pendulum, A, has ascended from the perpendicular line to the extremity of its arc, and has carried the arm, B, along with it. And the action of the scape-wheel has raised the gravity arm, C, from the stop, D. The pendulum will now return and continue its course till it has reached the limit of its arc of vibration, carrying the gravity arm, C, along with it, and leaving the gravity arm, B, resting on the stop, E; but the action of the scape-wheel will again immediately raise the arm, B, a short distance from the stop, E, and the force thus gained by the scape-wheel raising the gravity arms is the force which maintains the vibrations of the pendulum.

Some reader may ask why this can impart a force necessary to maintain the motion of the pendulum. We will suppose that the gravity arms are raised by the united action of the pendulum and the scape-wheel, say two degrees; the scape-wheel raises them, say one degree, and the pendulum raises them the other degree when it has reached a point near to the extremmity of its arc of vibration. The distance the pendulum raises the arms is of no value in maintaining its vibration, but, on the contrary, they have a tendency to stop its motion. However, the force that has been gained by the scape-wheel raising the arms one degree, imparts the power necessary to maintain the vibration of the pendulum, because the arms have pressed on the pendulum for two degrees on its downward course, while the pendulum has pressed against the gravity arm for only one degree on its upward course, and consequently a force equal in value to the gravity arms falling one degree has been obtained.

The important point gained by the use of gravity escapements is, that a constant force is always imparted to the pendulum, and it is placed beyond the influence of the effects of dirt, or a changed condition of the oil produces on the force of the train, because the scape-wheel does not act so directly on the pendulum as it does in escapements of the Graham class. The scape-wheel simply raises the gravity arms, and if they are always raised the same distance they will always impart the same quantity of force to the pendulum. There is, however, one serious drawback to gravity escapements which does not exist in the Graham. As has already been mentioned in the beginning of this chap-

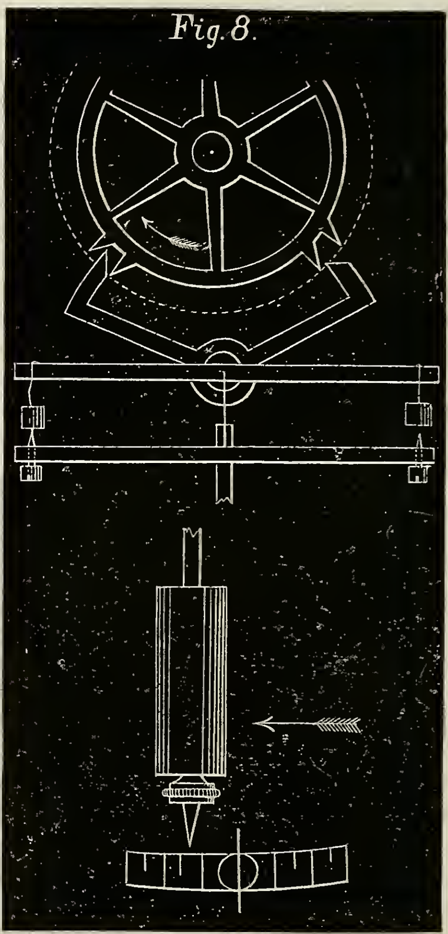
ter, the Graham escapement gives the impulse to the pendulum when it is near to the perpendicular line, while the resistance it meets with as it ascends on its upward course is always the same, because the scape-wheel teeth rest on a circle. Gravity escapements do not give the impulse to the pendulum when near to the perpendicular line, and when the pendulum ascends on its upward course, and the momentum of the bob is expended, and the force with which the pendulum moves grows weaker, the *resistance* the gravity arms present to the free vibration of the pendulum becomes greater in a like proportion.

For proof of this statement, let the reader refer again to Figure 6. If the gravity arm, B, is placed in the same position as it is in the diagram, it would not exert the same force falling a given distance as it would do falling the same distance when placed in the position of the dotted line, F, and the force would be proportionably greater if the gravity arm fell the same distance when in the position of the line G. This illustration will be sufficient to explain that the force of the gravity arm, B, increases as it is moved in the direction of the line G, and that the pendulum meets with a greater *resistance* from the gravity arms as it ascends



towards the end of the arc of its vibration. If a ball be placed at G, and the effective weight of the gravity arm be transferred to that point, as is shown in Fig. 7, this error will not be so great, and it will be diminished still farther if the balls be placed at an angle of 45 degrees above the line G, in Fig. 6.

Fig. 8 presents a simple and ingenious method of giving the impulse to the pendulum, through the agency of falling balls. It is the ordinary Graham escapement, with the pallets inverted, and a bar placed across their centre



of motion, as is shown in the diagram, and from the ends of this bar two small balls are suspended by a piece of fine silken thread. On the top end of the pendulum rod there is another bar fastened parallel with the one on the pallets, and the force of these weights falling on the points of the screws at the end of this bar gives the necessary impulse to the pendulum precisely in the same manner as in a gravity escapement. It is, however, liable to be affected in a way ordinary gravity escapements are not subject to. The slightest tremor of the clock causes the small gravity balls to vibrate, and when this happens the impulse is not given so regular as is necessary; still this difficulty may in a great measure be

overcome by placing the clock on a solid foundation.

COMPARATIVE ADVANTAGES OF GRAHAM AND GRAVITY ESCAPEMENTS.

The accuracy with which the Graham and gravity escapements perform the duties required of them may be summed up as follows. The Graham escapement imparts the necessary impulse to the pendulum near to that part of its vibration which mathematicians demonstrate to be the best place a pendulum can receive its impulse, and the resistance which this escapement presents to the free vibrations of the pendulum is simply the friction of the scape-wheel sliding on the circular part of the pallets; however, this resistance is liable to vary according as the pressure of the teeth of the scape-wheel varies, and the effective force of the impulse is also liable to vary from the same cause.

In gravity escapements a slight variation in the force of the scape-wheel is not felt on the pendulum, because the pendulum receives its impulse independent of the scape-wheel. The resistance gravity escapements present to the free vibrations of the pendulum increases as the pendulum approaches the extremity of its arc of vibration, and is in some respects similar to the resistance an ordinary recoiling escapement presents to the vibrations of a pendulum, whereas the resistance ought to become gradually less as the pendulum reaches that point.

In situations where clocks cannot be fastened in a firm manner, the Graham escapement is likely to perform the duties required of it the best, because any tremor in the suspension of the pendulum sufficient to cause it to slightly change its arc of vibration only produces a greater or less degree of friction of the teeth on the circular part of the pallets, and the *resistance* the pendulum meets with in its oscillations only varies in a slight degree. The same change in the arc of the vibration of the pendulum with a gravity escapement causes it to meet with a greater or less degree of *resistance* from the gravity arms, for it has already been pointed out that the force of these arms varies according to the angle which they are moving in. Still, when the clock is placed on a solid foundation, a properly constructed gravity escapement will maintain the motion of a pendulum in the same arc of vibration for a longer time than a Graham one will do. There is a strong prejudice existing among some watch and clockmakers that gravity escapements are liable to trip, and so they are if made by people who don't understand them. A chronometer escapement is subject to the same fault if the detent spring is not properly made. This prejudice against gravity escapements is nothing but a prejudice, for when properly made they are as safe against tripping as any other, as will be shown in a future chapter.

GRAVITY ESCAPEMENTS IN CHEAP CLOCKS.

Of late years there has been considerable talk among the clockmakers of London on the subject of constructing a cheap class of astronomical clocks with gravity escapements; but, with all due deference to the opinions of the brethren in London, I consider a gravity escapement in a *cheap* clock is neither necessary nor desirable. It is generally supposed that a gravity escapement admits of the use of a rougher train of wheels and pinions, but there must be a certain amount of accuracy in the wheel work, else the gravity arms will not be raised at the proper instant, more particularly if the scape-wheel has but few teeth, and moves a long distance at each vibration of the pendulum. A train fit for this purpose is sufficiently accurate for the purpose of a cheap clock when the Graham escapement is used. There may, however, be people who think differently, and therefore in the course of this essay I will give plain practical instructions regarding the construction of a regulator with a gravity, as well as one with the Graham escapement.

ON THE LENGTH OF THE PENDULUM.

It has been the almost universal practice to make the pendulums of regulators the length necessary to make one vibration in a second, and the long continued practice of making them this length has given rise to an idea that there is some peculiar time-keeping quality in pendulums of this length, but this is a mistaken notion. A pendulum slightly longer or slightly shorter would be equally effective in regulating the motion of a regulator, but it would not divide time into exact seconds. It is because a pendulum about 39.2 inches long vibrates once

in a second that this length was first adopted, and it is this reason alone that has caused it to continue to be the standard pendulum since.

The late Charles Frodsham, of London, expressed his opinion to an American Professor of Astronomy a few years ago, that it would be better to make the pendulums of Astronomical clocks very much shorter, so that the difficulties of compensating them accurately would be the more easily overcome. There is no doubt about the fact that a pendulum of the length necessary to vibrate once in half a second would be more easily compensated than one of the length necessary to make a vibration in one second. There is also but little doubt of the fact that a half-seconds pendulum would have sufficient dominion over the motion of such a delicate machine as an Astronomical clock is; still, so far as I can at present learn, the practical benefits which would result from the use of a half-seconds pendulum is as yet only a matter of conjecture, and for the present we will adhere to the well-tried seconds pendulum, and construct our proposed regulator accordingly.

[TO BE CONTINUED.]

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☞ In view of the fact that at the present time there is no subject connected with horology in which there is felt such a universal interest as that of the isochronism of the balance spring, we do not consider it necessary to apologize for devoting so large a portion of the present number of the Journal to the very able Essay of Mr. Moritz Immisch on that subject, and knowing that it will receive the careful consideration of every reader, any especial allusion to its merits would be equally superfluous. The Essay is published in book form, and is for sale by Messrs. H. H. Heinrichs & Co., 8 & 10 John Street, to whom we are indebted for a copy.

In the next issue will be presented the promised article from Prof. Eggleston, on the Angles of Tools, and which we think will be of especial interest to every reader of the Journal.

The constant demand for the first volume has made its reprint necessary, and we take pleasure in announcing that in a short time it will be ready for delivery. For particulars see advertising pages.

PRIZE ESSAY

ON

THE BALANCE SPRING AND ITS ISOCHRONAL ADJUSTMENTS.

(BARONESS BURDETT-COUTTS'S PRIZE.)

BY MORITZ IMMISCH.

The Balance Spring has often been called the soul of portable time-measuring instruments, and any one at all partial to figurative language, will own that it fully deserves the appellation, inasmuch as from its importance, delicacy, sensitiveness, and independence of action, it may well be likened to the predominating mind, which, though it derives its sustenance from the body, governs in its turn all the actions of the latter. Watchmakers are all the more tempted to make a comparison of this kind on account of the uncertainty under which the majority of them labor with regard to its properties and the laws which govern its actions.

One can scarcely be surprised at the prevailing ignorance in this respect, as there is very little reliable information to be found in books on watchmaking which could at all serve as a guide, and as a sound base for self-improvement.

The principal aim of watchmaking is correct measurement of time, and it must be confessed that in this respect, judging from the average performance of what are called first-class watches, there is ample room for improvement. There is no doubt that a proper knowledge of the nature and correct adjustment of the balance spring, especially with regard to isochronism, is of the utmost importance.

This manifests itself very strikingly, when we see that frequently a watch or chronometer of inferior make and even faulty construction goes admirably, and with a regularity which in some cases is perfectly astonishing; while, on the other hand, the highest degree of perfection of the escapement, the most exquisite finish of the trainwork, is unavailing to produce good performance if the balance spring is faulty or imperfectly adjusted.

It is to the introduction of the balance spring that watchmaking as an art may be said to owe its very existence.

There certainly was a kind of watch made before its invention in which the vibration of the balance was kept up by the recoil it met with in the escapement, the momentum of the balance being alternately destroyed and renewed solely by the direct operation of the motive force. This mode of obtaining a vibrating motion was no doubt extremely ingenious, but it is evident that any of the unavoidable irregularities to which the available impelling force of the fly-wheel is always subject, would tell immensely upon the balance, modifying its speed to such an extent as to make these watches next to useless for practical purposes. The principles upon which these machines were constructed, precluded the possibility of their being materially improved, and they would have remained, what in fact they were then, objects of curiosity rather than of utility.

It was reserved to the genius of the celebrated Dr. Hooke, who in the middle of the seventeenth century discovered the use of the balance spring, to supply the wanting elements of perfectibility, and to raise watchmaking from its primitive state to the rank of a beautiful and beneficial science.

His keen intellect perceived at once the immense advantage of giving to the balance an independent motion of its own, by means of which it was enabled to exercise a proper control over the irregularities of the motive force, and to neutralize their effects. His scientific investigations of the nature of springs, and his inquiries into the laws that govern their action, led him to his celebrated maxim, "ut tensio sic vis" (the force of a spring is as its tension), that has made his name famous for ever. With a view to solve the problem of determining the longitude at sea by means of a correct time-keeper, he applied for a patent; it was not carried into effect, however, on account of a serious disagreement between him and some enterprising gentlemen of position, in conjunction with whom the Doctor intended to work the patent at first, and he determined to leave the matter dormant for a time. It soon transpired, however, and "pendule watches" were made by several watchmakers in London soon afterwards. We find, too, that later on, several French watchmakers were quarrelling amongst themselves about the priority of the same invention, but this can only mean the priority of application, inasmuch as from documents still existing it appears that some of them had been in communication with the same parties who had failed to come to terms with Dr. Hooke, and it is more than probable that they suggested the idea to their French correspondent.

Considering time and circumstances, the beautiful combination of balance and spring must be put solely to the credit of Dr. Hooke.

Applied to the old verge escapement, the difficulties in the way of good performance were still very great on account of the recoil; but as this could now be dispensed with as a means of bringing the balance after a first impulse back into a proper position to receive the next, the idea of dead-beat escapements suggested itself, and Hooke contrived one which, though it had still a slight recoil, contained the elements and was suggestive of the duplex escapement which was invented some fifty years later by Dutertre, a French watchmaker.

In the course of time a good many of these escapements came into existence, but it was not until the free detached escapements made their appearance in the latter part of the eighteenth century, that the real properties of the balance spring could at all be tested with any chance of arriving at some definite conclusions.

Before that time the greater or lesser friction of the acting parts of the escapements continuing throughout the whole of the vibration made it a matter of great perplexity to reconcile the results actually observed with Hooke's "ut tensio sic vis," and as the theories founded on experiments with one escapement were at variance with the results of experiments made with another, we cannot wonder that the opinions concerning the spring were undecided and sometimes contradictory.

As an instance illustrative of the extreme difficulties in the way of properly understanding the conditions under which the balance spring acted, I may mention that in 1766, more than a hundred years after Hooke's invention, Cumming, in his book "Improvements of Watchwork," describes a dead-beat escapement, and in experimenting with it finds that its behavior in long and short vibrations was so different to what it was with other escape-

ments, that he comes to the conclusion "that hitherto the effects of the maintaining power have been mistaken for the natural tendency of the pendulum spring."

The detached escapements, as they were invented and gradually improved, reduced the friction, that great enemy to steady motion, to a minimum. The emancipation of the balance and spring from the influence of the maintaining power permitted the conditions of their motion and their relation to each other to be considered as separate features; by means of inferences the remaining friction in the escapement became a known quantity with determinable limits, which could, by turning the acquired knowledge of the properties of the spring to a proper account, be successfuly contended with; and what was before quite illusory—the realization of the much-cherished idea of determining the longitude by means of a watch—became now more feasible. We see watchmakers of that period exerting their utmost skill to attain that end, the large reward connected with it no doubt acting as a powerful stimulant to their energies.

The spirit of controversy being aroused, various and sometimes contradictory theories were advanced in books and pamphlets. The principal aim still seemed to be the further perfection of the escapement, and it makes one sad to think that so much incessant labor should have been thrown away without directly furthering the end in view; as, for instance, in the case of Mudge, who constructed a remontoir escapement so bold and original in conception as to find, simply considered in the light of an ingenious mechanical contrivance, scarcely a parallel in the whole history of watchmaking.

This memorable period of competition was, notwithstanding the frequent mistakes, productive of results extremely salutary to the advancement of horology as a science. Failures of some artists served as examples not to be followed, marking a path to be avoided, and inducing others to look for success in other directions.

The detent escapement being almost exclusively adopted for chronometers, as combining the least friction with the greatest simplicity, the balance spring now received a greater share of attention than heretofore.

Up to the time of Arnold, balance springs were made in the flat spiral shape. With him originated the cylindrical helical spring. The ends of this spring are bent inwards, forming a curve, within the circular space of the coils; the greater or lesser abruptness of these curves affects greatly the action of the spring in long and short vibrations, and is therefore determinable by the exigencies of each case.

Somewhat later the Breguet spring made its appearance, deriving its appellation from its inventor. The body of this spring is flat, but the outer coil is bent upwards with a gentle sweep; at some distance from the flat part of the spring it again forms a knee downwards, in order to bring its length parallel to the plane of the spring; from there it is bent inwards, forming a curve gradually tending towards the centre, similar to that formed by the ends of the helical spring.

I have to mention another spring, which, on account of its form when seen sideways, is called the spherical spring. It was invented by Houriet, a Swiss watchmaker. While in the cylindrical helical spring all the coils, except the curved ends, are of equal diameter, the diameters of all the coils of a spherical spring are different from one another, being largest in the middle and lessening towards the ends.

The specific advantages and disadvantages of these different forms of springs will hereafter be gone into.

I may here mention that the cylindrical form has, with very few exceptions, been adopted by English makers for marine and pocket chronometers, and the high reputation of superiority the English chronometer enjoys, and always has enjoyed, speaks volumes in its favor. One of the principal advantages afforded by this form of spring consists in the facility with which it permits those manipulations to be performed which are necessary to enable the spring so to control the motion of the balance that the long and short vibrations are performed in equal times.

This state of uniformity is called isochronism. We find that it is practically impossible to procure equal arcs of vibration for any length of time; the gradual increase of friction on account of the thickening of the oil will soon make the vibrations fall off, and in the case of pocket watches, the motion imparted to the

balance while being carried and the varying friction in different positions cause a considerable fluctuation in the length of the arcs; and as, in order to obtain a steady rate of going, any given number of vibrations, whether long or short, must be performed in a given time, it is evident that isochronism is the most important feature connected with balance springs.

A good deal has been said and written on isochronism, and where these writings have confined themselves to the practical side of the question in promulgating the results of experiments, describing the manner of procedure, the means by which isochronism can actually be obtained, they have no doubt done a great deal of good; but all endeavors to create a sound comprehensible basis for the various phenomena exhibited by different springs have proved more or less unsatisfactory.

There are those who are not satisfied simply to know what is to be done to procure isochronism, but are desirous to learn upon what principles these manipulations are based, *why* a change of form should procure isochronism, and why did it not exist before the change; and upon this important point it must be confessed that general knowledge is certainly deficient, not only amongst watchmakers, properly so called, but also amongst a considerable portion of those who have made springing and timing their specialty. Isochronism is a very intricate and complex topic in itself, but the difficulties in the way of mastering the subject have certainly been increased by the manner in which some writers have treated it.

When an opinion assumes the form of an authoritative dictum, without being based upon, and borne out by, unmistakable facts, it is very apt to mislead the student, waste his energies, and to discourage further investigations.

One of these so-called principles is the prevailing idea that isochronism solely depended upon a certain length of the spring; that too short a spring made the small vibrations slower than the long, and too long a one caused the watch to lose in long vibrations. This is so far from being correct, that sometimes in the case of a very long flat spring, it is a matter of the greatest difficulty to make the long vibrations slow enough to arrive at isochronism, while a shorter spring offers more scope for any manipulation tending to that end. Every one with some experience in timing, knows that mere length has absolutely nothing to do with isochronism, and if, nevertheless, we frequently meet with this assertion in books on watchmaking, it proves that it was simply copied from other books, without having been tested by the writer.

Another very general idea is, that isochronism is an inherent property of the balance spring. This is also incorrect, and to assume that, because by means of the spring isochronism can be arrived at, the conditions constituting isochronism must be looked for in the spring, is not quite but nearly as wrong as if anybody was to assert that, because licorice cures cough, the conditions constituting cough must be looked for in the licorice.

I have already mentioned the difficulties Cumming, nearly 100 years ago, experienced in accounting for the different performance of springs when in connection with different escapements, and the very natural and sensible conclusion he came to; and although escapements of the present day are far superior to those of that time, there still exists sufficient difference between them to make it a matter quite out of question, for instance, that a balance and spring perfectly isochronous while attached to a chronometer should retain this quality when attached to a lever escapement, unless it was by the merest chance, viz., if the chronometer was badly constructed and the lever escapement in a state of perfection, the difference being so proportioned as to make the sum of friction in the one amount exactly to that in the other; otherwise, and under ordinary circumstances, the balance spring perfectly isochronous in the chronometer would be sure to perform the long vibrations quicker than the short ones in the lever watch; but it is not at all necessary to bring the balance and spring in connection with different escapements in order to prove that the resistance in the escapement modifies the isochronal conditions, as carefully conducted experiments with one and the same escapement will show that every increase and decrease of friction affects the motion of the balance in lo or short vibrations more or less sensibly.

A still greater factor in this respec balance itself; and before I consid relation to isochronism, I think i make some general remarks o

When a balance without a spring is brought into connection with a chronometer escapement and turned in the direction of unlocking, the escapement will cause it to revolve round its axis. There is first of all a certain amount of force required to overcome the inertia appertaining to all bodies at rest; *this is a dead loss*, and irrelevant as this may seem to many who have applied themselves to the study of the laws of isochronism, there will also be those who, by inference and actual observation, have found that great importance attaches to this point, and that it bears directly upon the subject of isochronism, as will appear hereafter.

The impulse given, the balance revolves round its axis with a speed greater or less according to the greater or smaller proportion the propelling power bears to the resistance to be overcome; after a whole revolution it presents itself to another impulse, and arrives at this point with a velocity somewhat less than that with which it started, the loss arising from the friction of the pivots, the resistance of the air, and the unlocking of the escapement. To this velocity another impulse is added, which causes the second revolution to complete itself much quicker than the first; the diminution of speed caused by the retarding influences already mentioned, is now much less apparent, as the greater momentum acquired by the balance enables it to overcome them easier, and soon the balance acquires so much force of its own as to leave no perceptible trace of lessening of speed between the commencement and the end of each revolution. This is, however, under the presupposition that the balance is of some considerable weight and diameter: different balances will behave very differently in this respect; a more substantial one has a greater capacity for retaining and accumulating any force transmitted to it, and will consequently exercise a greater controlling power over the impediments in the way of uniform motion.

In all cases, as impulse is added to impulse, the velocity will go on increasing until a maximum is reached, where the speed remains stationary. After what has already been said, it is evident that a slighter balance, owing to its more yielding nature, will arrive at this point of uniformity sooner than a more substantial one; but irrespective of the time required by different balances to arrive at this maximum state of velocity, that state itself is determined, not only by the sum of the various influences already mentioned, but also by the inertia of the escape wheel and train, which has first to be overcome by the motive force, causing a loss of time.

This loss is of no importance when the motion of the balance is slow, as the acting tooth of the escape wheel will then come in contact with the pallet as soon as the latter has fairly entered the circle of the former, and the balance receives the full benefit of the impulse as it is acted upon through the greatest possible arc; but as the velocity of the balance increases, the pallet will enter the circle of the escape wheel quicker and will have proceeded farther in it before the sluggishness of the escape wheel and train has been overcome; and in proportion as the "drop" increases, the effectiveness of the impulse decreases, until at length it is counterbalanced by the above-mentioned retarding influences, and the motion remains stationary. It may be as well to mention here that in the case of maximum speed, the resistance of the air is a more important retarding agent than when the motion is slower, as it increases in the ratio of the squares of the velocity.

All these conditions determining the limits of the various influences acting upon the simple motion of a balance, remain in full force when this balance is connected with a spring. In the case of a *vibrating* balance the number of these conditions is naturally augmented by circumstances originating with, and various properties appertaining to, the spring.

When any external pressure is brought to bear upon a spring, changing its form in any direction whatever, this change invariably implies a shifting, a displacement of the relative position of the infinitely minute atoms composing it.

The spring contracts on the side towards which it is bent, compressing the particles of the material into a smaller compass, and expands on the other; the particles in the centre of the spring only retaining their relative positions. Within certain limits this displacement is only temporary; the pressure ceasing to act, the cohesive power of the particles causes them to reoccupy their original relative positions exactly, so that no trace is left of any change of form. If these limits are overstepped, they will

only partly reoccupy their former position, and a permanent change of form is effected. It stands to reason that the greater or less thickness of the spring greatly modifies these limits. If a thin spring is bent to a certain angle, the extreme contraction and expansion of the particles farthest from the centre will be less than when a thick spring is bent to the same angle of inflection.

These limits are also modified by the degree of hardness possessed by different springs; being smaller with softer and greater with harder springs. The force with which the spring returns to or towards its original shape, after having been forced out of it, is called the free elastic force. This free elastic force is in all cases somewhat less than the force employed in its tension, or, what is the same thing, somewhat less than the resistance which the spring opposed to the bending force.

The more the minute corpuscles composing the spring have to be displaced, in order to bend it, the greater this loss will appear.

If a balance is connected with a spring, it strikes us at once that the spring enters the list of those influences which are opposed to the motion of the balance, and it appears here as a very powerful factor, inasmuch as the effect of a single impulse, or the sum of a certain number of consecutive impulses, is much sooner absorbed with it than without it. If there was no impulse power absorbed in bending and unbending, if the recoiling force of the spring amounted exactly to the force employed for tension, a sprung balance would vibrate just as long as the same force would cause it to revolve round its axis, subject, however, to this qualification. that by the action of the spring the side pressure on the pivots is somewhat increased, which certainly assists to bring a vibrating balance sooner to a standstill; but this influence of increased friction, important as it is in other respects, bears only a small proportion to the loss occasioned by the change in the granular condition, which may be imagined as a kind of friction within the spring itself. This loss of force also varies slightly with the degree of hardness, being greater in softer, and smaller in harder springs. The force so lost to motion seems to be active in destroying the elasticity of the spring. In very thick and soft springs this diminution is so rapid that sometimes a few years' use will cause such a difference of elastic force as to necessitate the re-springing of the instrument.

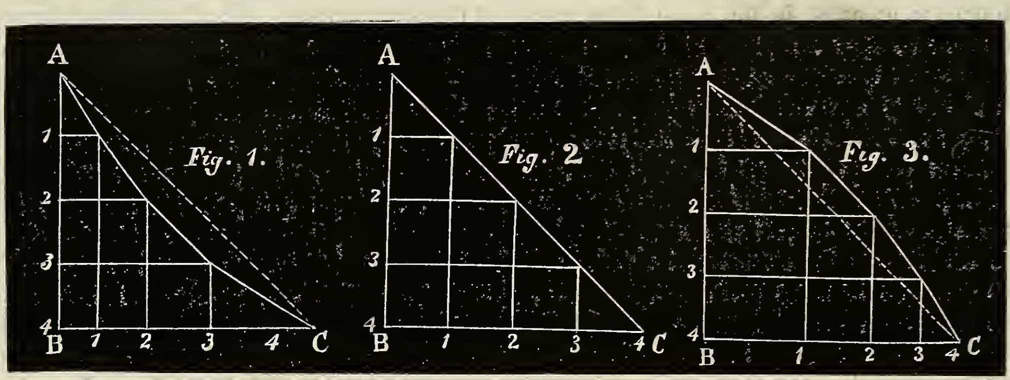
A vibrating balance has many points in common with the pendulum of a clock. As a pendulum gradually increases its arc of oscillation till it has accumulated all the force the motive power can impart, and till it is counterbalanced by the force of gravity which also accumulates, so do the vibrations of a balance increase till its acquired momentum is counterbalanced by the resistance which the tension of the spring opposes to a further increase of gyration. Although the force of gravity which causes the pendulum to continue its oscillation is of uniform intensity throughout, while the force of the balance spring differs in all points of the vibration, this dissimilarity does not prevent the two respective motions from being considered as identical in this respect, inasmuch as the *sum of force* in a spring coincides with that which actuates the pendulum.

Both pendulum and balance perform their respective vibrations in the same time, whether the arcs are large or small; in both cases, therefore, the velocities increase with the angle of inflection, and the resisting are proportionate to the impelling forces. This may be thus expressed: let line A, B (Fig. 1) represent the momentum, and line B, C the force of gravity; divide these lines into equal parts and draw rectangular lines till the corresponding ones meet; if we now connect these points of juncture we obtain the straight line A, C.

In the case of a balance the momentum is also uniform A, B (Fig. 2), but the resistance B, C is uneven throughout, being weakest at the beginning and strongest at the end of the vibration; by connecting the points as in Fig. 1 we get the curve A, C; but as the force has been increasing with the resistance, the return of the balance to the point it started from must now be expressed as in Fig. 3, the force being greatest in the beginning and smallest at the end; proceeding as before, we get the curve A, C, and as the distances from the straight line in both curves exactly correspond in all points, it is evident that after the completion of this part of the vibration the balance will arrive at the point it started from, with the same velocity as if both the forces had been uniform throughout.

In making experiments with pendulums we find that, without some auxiliary contrivance, the long arcs are performed slower somewhat than the short. This difference in the arcs is double when the weight is double, and the same increase takes place if the velocity is double. It follows that they originate with, and are determined by, the weight and the velocity, or what is the same thing, by the momentum of the pendulum.

The vibrating of a pendulum may be imagined as a struggle between the momentum and the force of gravity; at the end of each vibration when the gravity succeeds in overcoming the momentum there is a point of rest. If in the same moment this point is reached, the gravity should cease to act, the pendulum would remain in this position; as it is, there will be a certain amount of force required to overcome the inertia appertaining to all bodies at rest. This force so lost to motion is tantamount to a loss of time, as we have seen above in the case of the escape wheel and a rotating balance. It naturally follows that this state of rest will be prolonged by an increase and shortened by a diminution of weight. It also stands to reason that in the case of equal weights a greater velocity will put the force of gravity, which remains the same, to a disadvantage, the struggle will be prolonged, which also causes a retardation. The scientific explanation of this is to be looked for in the fact, that the point of percussion in a swinging body does not coincide with the point of gravity.



In assisting the force of gravity by applying a suspension spring, these irregularities can be contended with; as its force is at its tension, it will be greater at long than in short arcs; and if it is of proper length and thickness, and its force in proper proportion to the weight of the pendulum, it will cause the long and short vibrations to complete themselves in the same time; but, although by means of a suspension spring, isochronism can be obtained, it is far from being the sole agent in this respect, because if the weight is diminished the long vibrations will gain on the short ones, and *vice versa;* and again, if the weight be the same and the length diminished, the long will be slower than the short arcs; so that when the strength of spring and the number of vibrations are given, a certain weight will cause the vibrations to be equal; if strength of spring and weight are given a certain length will be required for that purpose. In making experiments with pendulums the influence of the resisting air must be taken into account. This resistance, as stated above, increases in the ratio of the square of the velocity, and inasmuch as it assists the force of gravity to overcome the momentum, it has a tendency of quickening the long vibrations. Experiments will show that with a very light pendulum presenting a very large friction surface to the air, the long vibrations are performed even quicker than the short; so that isochronism may be arrived at by a proper proportion between the weight and the friction surface of the pendulum; however, no watchmaker would think of resorting to this means, as such a pendulum would require a much greater force to be moved through the required arc. I simply mention this as a circumstance bearing on the subject, which must not be lost sight of in making experiments. Care must also be taken that the oscillations should continue in the same plane; if they are in the slightest degree elliptic the point of rest is not perfect, and the result unsatisfactory.

The knowledge and proper appreciation of these influences in connection with the vibrations of a pendulum will materially assist us in comprehending the elements of isochronism in balance and spring. Here we must substitute the *extremities* of the balance spring for the suspension spring of a pendulum, and the relative force of the balance spring for the force of gravity. This relative force increases and decreases inversely with the weight and the squares of the diameter of the balance; any change, therefore, in the dimensions of the balance involves a change of this relative force, which stands here in the place of the force of gravity acting on the pendulum, and which is uniform. If there existed several forces of gravity of different intensities which could be brought to act on a pendulum, the latter would require a different isochronal adjustment for each of these. In the case of a more powerful force, causing quicker vibrations, the momentum would be at a disadvantage, the suspension spring would have to be weakened, or the weight increased. In a watch calculated for quick vibrations, the balance is at a similar disadvantage, and experience proves that when the vibrations are very quick, watchmakers have sometimes the greatest difficulty in making the large vibrations slow enough to counteract the effect of the escapement friction, which invariably tends to retard the short vibrations more than the long. The reverse difficulty is experienced when the vibrations are excessively slow.

If the question should arise, why friction retards small vibrations more than large ones, it will find its solution in the fact, demonstrated by eminent horologists and mechanicians, that the effects of friction, detrimental to the free motion of a moving body, are inversely proportionate to the squares of the time employed to overcome it.

There is no doubt that the disposition of weight and diameter of a balance has a certain influence on isochronism. The diameter meant here is not the apparent diameter of its extreme circumference, but is determined by the distance of the centre of gyration from the centre of the balance. This centre of gyration corresponds to the centre of gravity of the pendulum, and its position varies with the form of the balance. If, for instance, the cross-bar is very heavy, the centre of gyration is nearer to the centre of the balance than when it is light.

In a compensation balance its position would much depend upon the thickness of the rim and the size and weight of the screws. We find that isochronism is differently affected when the relative force of the spring is diminished by increasing the weight, to what it is when this is effected to the same extent by an increase of the diameter. But as it is impossible to know the exact position of the centre of gyration in each balance, and owing to the consequent difficulty of knowing beforehand whether the addition of a screw, for instance, affects the distance of this centre and the weight alike, or one more than the other, any attempt to procure isochronism by this means must remain guesswork more or less.

The resistance of the air has upon a balance a similar effect as upon a pendulum. This is much more apparent in a large and light balance than in a small and heavy one, and it is partially owing to this cause that on the replacing of brass screws by others made of gold or platinum the long vibrations generally become slower.

By adding to or diminishing the weight of a balance by means of screws of different shape, and using materials of different specific gravity, we can obtain isochronism at a good many rates of going, the degrees of velocity themselves being powerful factors in this respect. The drawing out of screws, for instance, produces an unequal effect at different rates of going. Experiments of this kind can easily be made with any good watch or chronometer.

For the sake of illustration I shall note down the result of an experiment made with a lever watch having a Breguet spring, which was perfectly adjusted at 18,000 vibrations in an hour. I shall call the long vibrations V, and the short ones v.

A pair of small screws added........	V−18
	v−18
Another pair added...................	V−1′7″
	v−1 5″
Another pair substituted for a pair taken out..........................	V−1′0″
	v−1′0″
Two very small screws taken out, and all the others considerably drawn out	V−1′16″
	v−1′14″

The time of observation was an hour in each case, the watch remaining in the horizontal position. By using screws of different shapes and materials these experiments can be modified indefinitely, sometimes with most astonishing results. The inference to be drawn from these results is, that the active elements—viz., diameter, weight, velocity, and resistance of the the air—are partially opposed to each other, and if they are affected alike, or so that the balance of power between them is not disturbed, isochronism is not altered; if unequally affected, the result is a difference in long and short vibrations one way or the other. By making a great number of experiments with one and the same balance, the isochronal value of each of these elements can be ascertained, but any rule based upon these experiments would only be applicable to this identical balance; other dimensions, even the application of another spring, would necessitate another set of tedious experiments.

These facts will be sufficient to disprove the idea entertained by some watchmakers, that a spring adjusted in long and short arcs to a certain balance would retain this quality when attached to another of different dimensions, unless, indeed, it was by the merest chance; and, taking it for granted that isochronal adjustments depend upon the form of the spring, they will go far to explain why these forms differ when balances of different dimensions are used.

But if the elements constituting the momentum cannot with advantage be used to procure isochronism, there are certain rules based upon them which determine the diameter and the weight of the balance when in connection with trains calculated for different numbers of vibrations in a given time, in order to procure vibrations of a suitable extent.

We have already seen above that the relative force of the spring is inversely as the square of the diameter; a balance, therefore, of half the diameter of another would require four times the weight of the large one for the same number of vibrations. Here we have four times the weight projected half the distance of that of the large one, and in the case of the latter we we have one-quarter the weight projected only double the distance of the small one; and as in both cases the relative force of the spring remains the same, it follows that the smaller balance has double the capacity of accumulating and retaining any force transmitted to it, and will consequently cross further. If therefore a certain arc of vibration is to be obtained with a given mainspring power, quicker vibrations will require a smaller and heavier balance, and a larger and lighter one will be necessary for slower speed. It is a rule, established by practice and experience, that for marine chronometers the arcs should be one turn and a quarter; it has been demonstrated that with this arc magnetism has no influence on the rate of going, retardation and acceleration counterbalancing each other in each vibration exactly.

With that kind of dead-beat escapement, where the friction remains active throughout, as in duplex and horizontal watches, the gyration is of course much less, and here it is imperative that attention should be paid to a proper proportion of weight and diameter of the balance. In the case of a horizontal watch no amount of change in the balance spring will make long and short vibrations equal, if these proportions are incorrect. The friction on the sides of the cylinder is a given factor, and must be turned to a proper account; the gyrations being small in themselves, the arc of escape bears a large proportion to the whole extent of the vibration. During this arc of escape there is no side pressure against the cylinder, and a stronger impulse will consequently propel the balance forwards with a greater velocity. This increase during the arc of escape in a properly-constructed watch will be compensated for by the increased friction on the cylinder. If a balance is too small and too heavy it is clear that its greater momentum will overcome this friction easier, and so neutralize the equalizing effect it would otherwise have had. It follows if a horizontal watch gains with increased motive force, the balance is too small and too heavy. By making it lighter and putting a weaker spring a change is certainly effected in the right direction; but as any change in the motive force will bear too great a proportion to the absolute power of percussion in a slight balance and spring, any diminution will cause the vibrations to fall off considerably; any outward influence, as thickening of the oil, and imparted motion, will also influence the going of the watch to an

undue extent. There is in a large and light balance not that alertness which we find in small and heavy ones, and the wear on the edges of the cylinder is certainly greater, but it has the important advantage of greater steadiness. In a watch having an escape wheel of fifteen teeth making 18,000 vibrations in an hour, the extreme edge of the balance should just reach up to the tooth of the wheel, and the weight be so proportioned that, being clean and fully wound up, it should make a little less than two-thirds of a turn. With slower vibrations the size must be increased proportionately.

In a duplex watch the friction is much less; but as it continues throughout, a change of the momentum of the balance would also considerably affect the long and short vibrations. This escapement affords a facility of altering the proportions of the impulse velocity to the friction in the remainder of the vibration. If the angle formed by the pallets and the notch in the roller is lessened, the drop is increased, and the impulse power so lessened causes not only the vibrations themselves to fall off, but also the smaller ones to be slower than the large ones.

The following rule will be a guide in conducting experiments: All alterations which increase the arc of vibration without changing the amount of friction will make the long vibrations slower than the short ones. If the impulse power remain the same and the friction is increased, the long vibrations will be quicker than the short ones, inasmuch as to a smaller arc of vibration the same increase of friction bears a greater proportion than to a larger one.

If in a duplex watch the balance holes are too large and the balance is brought into such a position as to bring it into a closer proximity with the escape wheel, the long vibrations are sure to be quicker than the small ones; for two reasons, firstly, on account of increased friction on the roller; and, secondly, in conquence of the greater drop in the escapement. The difference caused by greater or less drop will be the same whether the momentum of the balance is great or small, while that caused by the change in friction on the roller will be considerably influenced by the momentum of the balance. We also find that if the balance holes are large, a considerable difference arises in the rate of going in the four vertical positions. The pressure of the wheel against the roller is never directed to the centre of the latter, but acts obliquely, and if, according to what position the balance is in, it becomes more or less so, it will cause a variation of friction in the pivots in different positions; though it is less in amount than that on the roller, it is extremely inconvenient, as its variable effect can never be entirely compensated for. It is therefore of great importance in a duplex watch that the holes should fit exactly. When the escapement is set out of beat, the point where the vibrations are quickest does not correspond with the centre of the arc of escape, and, therefore, such a change will have an influence on isochronism; but of course this cannot or ought not to be done, as it would make the escapement imperfect.

In a duplex watch the friction on the roller is sufficient to exercise a proper control over the momentum of the balance, and, consequently, the latter becomes liberated and gets more free in its action when the motive power relaxes. The balance is, on the other hand, sufficiently independent of the friction to allow the properties of the balance spring to be brought into play. Those circumstances combine to make the general performance of duplex watches very satisfactory. In lever watches and chronometers the motion of the balance is, except during the arc of escape, unfettered by any escapement friction, and the properties of spring and balance have their full sway.

We have already seen that a change in the momentum can not be resorted to with advantage to procure isochronism; and as by means of a spring it can be obtained with the utmost precision, this mode is invariably employed.

An opinion exists amongst a great number of watchmakers that isochronism is arrived at when the angle of inflection corresponds exactly with the force of the spring; but, by what we have already seen, this cannot be correct. If apart from the momentum of the balance (which certainly plays an important part in this respect) any *change* of drop or friction influences isochronism, *the unavoidable and given friction and drop must therefore be factors and agents of more or less importance when the isochronous state is obtained.*

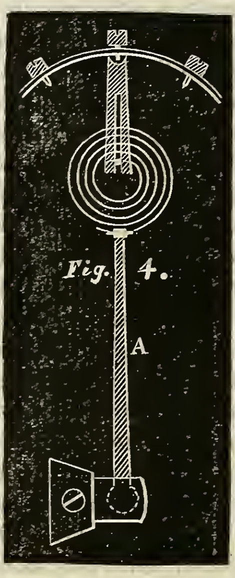
Before I describe and explain the nature of the manipulations necessary to obtain isoch-

ronism, a few general observations will not be out of place.

If a piece of spring, say part of a mainspring, is fixed at one end with its concave side upwards, a weight will draw it lower down than when the convex side is upwards; therefore when a balance spring is inflected towards that side where the coils recede from the centre, it would oppose less resistance to the balance than on that side where they advance towards it, and the halves of the vibrations would be unequal in length if this was not counterbalanced by the circumstance that the strain of the cohesive power of the corpuscles composing it is greater here than when it is inflected the other way. Supposing a spring to have three turns; when inflected one whole turn to make the coils expand, the turns will only be two; when inflected the other way one whole turn, the turns will be four, and therefore as 3 : 2 is a larger proportion than 4 : 3, the spring had in the former case to expand more than it had to contract in the latter.

If the above experiment with the piece of spring is continued (the convex side being upwards), it will be seen that in the beginning the spring bends closest to the centre, but farther on (supposing the bending force always to act in a rectangular direction to the tangent of the extremity of the free end) the form will soon become of an oval shape, and if the spring should break now, it would not be at the point of fixture, but at the point farthest from it. Had the spring broken at the beginning of the experiment, it would have been much nearer to the fixing point. This experiment, rude as it is, proves that the point of the greatest strain moves away from the fixing point when the spring contracts, and approaches towards it when it expands. This is exactly what takes place in every spring. In the case of a flat spring, that strain is modified by the relative position of the ends. The following experiment, which can easily be repeated by any one, will prove this beyond a doubt.

I fixed the outer end of a spring of five turns to a movable stud or lever (A, Fig. 4), turning on pivots at some distance from the spring. One of the balance arms had a long notch in it to receive a stud in place of the collet, to which the inner end of the spring was fixed, and which could be easily moved to and fixed at any distance from the centre. In setting the balance in motion, the lever, of course, moved to and fro, turning on its pivots always in the same direction as the balance moved, no matter whether the spring was fixed as in the drawing, or the reverse way. I found the lever A to move very differently according to the relative position of



the ends; sometimes equally to and fro, sometimes much more when the spring expanded than when it contracted. These differences were about the same in each coil, provided the relative positions of the ends were the same, only they were more conspicuous as the spring got shorter. The greatest deviation of the lever I found when the ends were fixed about half-way, making $4\frac{1}{2}$, $3\frac{1}{2}$, and $2\frac{1}{2}$ turns.

In tapering the outer coil of a similar spring towards the end, the movement of the lever became much less, because here the point of the greatest strain was confined to the immediate neighborhood of the fixing point. It follows that the greatest deviation of the lever from its quiescent position denotes that the greatest strain is as far from the end as it possibly can be. These imperfections, if I may so call them, are made use of to procure isochronism in flat springs.

If the strain is too near the end at the commencement of the vibrations, there is not suffi-

cient room for it to advance farther, the cohesive power of the particles of the extremities of the spring will be overstrained when the vibrations get larger, causing them, of course, to be quicker.

On the other hand, when the strain at the beginning of the vibration is farther from the end, it has more scope to travel forward, the momentum of the balance will be more powerful (comparatively speaking) in long vibrations, the point of rest before the return of the balance will be prolonged, and, consequently, the long vibrations will be slower. There is, therefore, a certain relative position in every flat spring where the long vibrations are slowest, and another where they are quickest; but whether the difference between the two is sufficient to meet the exigencies of the case, is another question, and depends on the conditions considered at length above. That difference, as we have seen in this experiment, decreases with the length of the spring, and it is found by practice that it *increases* with the proportion in which *the distances of the coils from each other are tapering towards the centre.* In a very long spring where these distances are equal it is very small. If, as is usually the case, index and curb pins are used to bring the watch to time, this, of course, alters the isochronal properties of the spring. Curb pins can therefore be used to procure isochronism if timing screws are used for rating the watch; but this can only be done within comparatively narrow limits, as when the curb pins are too far removed from the stud, the unemployed end will slightly move in a contrary direction to that of the spring, and as this movement is caused by the strain of the employed part, it will in its turn affect the vibrations. The differences arising out of such a compound motion have no definable limits, and must therefore be avoided.

In any alteration of the spring effected for the purpose of making the long vibration slower, the weight of the balance should be altered. It is best to operate on a pair of small screws close to the rim of the balance; the changing of the diameter sometimes entirely destroys the beneficial effect the lengthening or shortening of the spring would otherwise have had.

A greater or less tapering of the distances towards the centre will vary the relative positions of those points where the difference between long and short arcs is greatest, and these relative positions must be found out in each case.

A flat spring should have about eleven turns. If shorter, it must be harder in proportion, on account of the greater strain. The distance of the coils farthest from the centre should be about twice greater than the innermost ones.

Formerly springs were often made tapering, to procure isochronism. This mode was first employed by Berthoud, and there is no doubt that isochronism must be obtained by that means if the taper is properly proportioned; but the difficulty in the way of making these springs has brought them into disuse.

In Breguet springs isochronism is obtained by bending the outer end, and in cylindrical or helical springs by bending both ends into curves towards the centre.

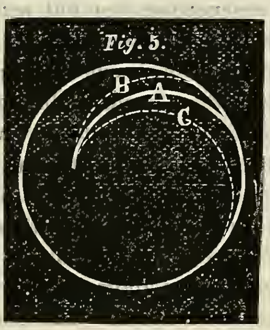
By what has been said in the case of the flat spring, it will be extremely easy to understand the nature of the change effected by this manipulation. If we compare the inner coils of a flat spring with the outer, and try to bend them by opposite central forces, with a pair of tweezers for instance, we find that the outer coils give way much easier, which proves that the smaller have a greater degree of rigidity; by bending the outer turns towards the centre, therefore, we impart more rigidity to the end, causing it to oppose a greater resistance to a bending force, so that when the vibrations are small the greatest strain is farther from the centre, and the same argument I advanced in the case of a flat spring remains here in full force. It stands to reason that if the curve is too abrupt, the length to which this greater rigidity is imparted is shorter; if the curve is more gentle, beginning farther from the end, the greatest strain will be farther from, and will be enabled more gradually to advance towards, the fixing point.

If, therefore, the watch loses in long vibrations, and the curve of the spring should have the form A, Fig. 5, it will have to be changed to a form approaching B; and if it gains in long vibrations the curve must be begun farther from the end, approaching the form C.

It is evident that a helical spring, having both ends turned in, offers a larger scope for operation than the Breguet spring. Both, however, have the important advantage in com-

mon, that they emancipate the balance from the side pressure of the pivots in their holes.

The outer end being fixed within the circle of the spring, and the curve itself expanding, the free end of the curve, which is also the commencement of the circular coil, is enabled to recede from, and to advance towards, the centre, according to the direction in which the



balance is moved, while when the extreme end of the last circular coil is fixed the expansion and contraction is one-sided, causing a side pressure in their holes; we can therefore, with a Breguet or cylindrical spring, obtain a greater arc of vibration with a smaller amount of motive force.

In the case of spherical springs, a greater rigidity is given to the ends, not only by the smaller diameter of the outer coils, but also by the different inclinations which the flat sides of the spring have to the plane of the motion. It is only the centre coil the sides of which are exactly rectangular to the plane of motion, and will therefore be affected most.

This isochronal adjustment of this spring consists in lengthening and shortening it, and bringing the watch to time by altering the balance in the manner described above.

This spring stands in the same predicament as the tapering flat one, and as no particular advantage attaches to this form which would compensate for the greater difficulty in making it, it is very seldom resorted to, and belongs to the class of fancy forms, if I may use this expression.

We see that in all these different forms the principle of adjustment of isochronism is the same, although the manipulations differ.

The motion of a spring may be imagined as a struggle between the body of a spring and the extremities. Although when the spring is inflected *all* the coils bend, it is in point of fact the resistance of the extremities which checks the force of the momentum of the balance. It stands to reason that in order to have the greatest strain at the proper distance from the centre the absolute elastic force of the body of the spring must be exactly even throughout its whole length, or (in the case of flat springs) exactly proportionate to the length, because if this proportion is not even, and there should be a weak place in any part of it, the greatest strain would be *there*, and not where it ought be, and any change effected in the extremities will be more or less ineffective. It is therefore of the utmost importance that the degree of hardness should be absolutely uniform throughout the spring. Care should also be taken that the body of the spring should not get bent, as the rebending it to its former position causes an unevenness of the texture of the metal. The unevenness caused by such a proceeding will be greater when the material is soft.

If we bend a piece of metal and try to bring it back to its former shape, it will bend in a different place; everybody knows how difficult it is to straighten a pin when it has been bent. If a spring has been bent and it is *forced* back into its original position, the elastic force will be diminished at the point so forced. The mere fact of bending it in the first instance has an effect detrimental to its elastic quality. It is, for instance, well known to watchmakers, and many have found it out to their trouble, that the bending of a gong wire in a repeating watch, in order to free it from any point it touched, diminished the sound considerably, and heating the spring would only partially restore the tone. The best way to proceed in such a case is this: if the spring touches on the outside and must consequently be bent inwards, it should be, at the place where it is to be bent, laid upon a convex piece of brass corresponding in shape with the inner side of the spring; then if the outside be slightly hammered with the sharp edge of a hammer the small indentations produced will cause the outside to be lengthened a little and the inside to contract in proportion. The change of form will be very gradual, and the granular disturbance, being spread over a larger area, will not be great enough to affect the tone in the least. The more a spring is bent to and fro in any direction, the more it will lose its

elastic force. It is for this reason that a beginner will often spoil a spring by over-manipulation, making it ultimately unfit for isochronal purposes. Especially in soft springs care should be taken to make any change very gradually, and rather oftener than too much at once, and thereby necessitating the bending back of the spring. If quite a soft spring, perfectly adjusted, should be bent and brought back again to exactly its former position, the vibrations would be isochronous no more, and by repeating the experiment the elastic force of the curve will become so small compared with that possessed by the body of the spring, that, instead of exercising a control over the latter, its motion becomes subservient to it. A harder spring will bear a much greater amount of over-manipulation, and a Breguet spring, the form of which in itself necessitates a certain amount of bending, must always have a greater degree of hardness than that necessary for helical springs, in order that the advantage possessed by this form should be of the greatest possible use. It is also necessary that a certain time should elapse before ascertaining the result of the change effected.

All metallic bodies possessing some degree of elasticity do not, if forced in to a different shape, retain the newly acquired shape exactly, but have a tendency to return, in some small measure, towards that shape from which they have been forced. The reactionary force becomes gradually less active, until, after a time, it ceases altogether. The time required for the shape to become permanent differs greatly with the degree of elasticity. This time will be greatly shortened by the application of heat, and also by imparting some small motion. A great variety of experiments may be made to prove the existence of this most curious phenomenon.

A gong in a repeating watch, after the tone has been spoilt, will after a time, especially if the watch is made to strike frequently, in a small measure improve its tone. This improvement will take place at once, and in a greater degree, if heat is applied.

There is no form more favorable to the display of this tendency than that possessed by balance springs and the acting parts of a compensation balance. If a compensation balance is bent outwards rather considerably, and the rate be noted down, say, after the first half-hour, and compared again somewhat later, say, after six hours, it will be found that at the second observation the rate is somewhat accelerated. While this change is taking place in the balance spring the isochronism is affected in a manner which is very deceiving, because it is not continuous. To bring this feature more directly under observation, the following experiment can easily be made. Bend a part of mainspring (of about six inches in length) excessively, not by short bends in different places, but by a continuous twist between the fingers, and then bend it back again gradually and by short bends in different places till it forms a straight line; then fix one end firmly on a table with its sides vertical to the plane of the table in such a manner as to allow the free end to vibrate freely in a horizontal direction; fix a small weight to it at a convenient distance, in order to make the vibration observable; mark the position when in rest by fixing a pin into the table outside the spring, and two other pins at *equal distances* from the spring. If the spring is inflected in that direction from which the last change has been effected in making it straight till it touches the pin, it will, on being released, not reach the opposite pin by far; in being as much inflected the other way and released, it will either reach the opposite pin, or at least approach much nearer to it, which proves that the resistance which the spring opposed to the momentum of the weight is greater on one side than on the other. Something of this kind takes place (of course in a very much smaller measure) in the balance spring after it has been altered, and it would be quite useless to ascertain the permanent effect of a change before the lapse of a certain time. In the case of a hard spring in a chronometer, a time of about three or four hours should be allowed.

In adjusting the spring of a watch in long and short vibrations, the short ones must be made to gain upon the long when placed horizontally, because it will be found that in the vertical positions the vibrations are smaller on account of the increased friction on the pivots, and the watch will lose; this retarding influence varies of course with the proportion the friction bears to the momentum of the balance, and must be compensated for in order to obtain good performance. In the case of marine chro-

nometers, only the retarding influence of the thickening of the oil comes into consideration, and it has been found best to make the short vibrations gain upon the long ones about 6″ in 24 hours when the arcs are reduced from one and a quarter to three-quarters of a turn. The opinions of chronometer makers differ as to the amount, and this will always remain a weak point. Very often we find that, without any assignable reason, the oil corroded on some pivots much more than on others. In fact, it is seldom that we find the thickening taking place quite uniformly, and if it takes place more on the pivots of the wheels than on the pivots of the balance, the rate will be accelerated, and *vice versa.* There is no doubt that the use of constant power escapements would do away with this difficulty, whatever may be the objections against them in other respects.

There is a peculiarity of balance springs which is as important as it is vexatious, and which is the greatest obstacle in the way of correct time-keeping. It is their different performance in different temperatures.

All bodies expand in heat and contract in cold, and if that was all in the case of a balance spring, it could easily be compensated for; but we find that, besides its getting longer, its elastic force also changes considerably in different temperatures. These changes take place in an increasing ratio, and this ratio itself varies and increases, with the degree of hardness possessed by the spring The compensation balance commonly used to correct this error in the spring is also irregular in its motions, inasmuch as when the rims bend inwards the weights proceed more directly towards the centre, and have a greater effect than when they bend outwards; and although this circumstance tends to lessen the fault produced by the spring, it does not do so sufficiently, especially with hard springs. If, therefore, a chronometer is adjusted in the middle temperatures, it will lose in both extremes. If adjusted for one extreme, the fault will be greater in the other. These irregularities combine to make the subject of compensation in heat and cold a very intricate one. The present essay has only so far to do with it as it involves certain properties of the spring.

By what has been said, it would appear that in determining the degree of hardness in a spring we have to choose between two evils. A soft spring will be too short-lived, and a hard one will be too capricious in its tendencies. The best plan, therefore, in this case is to choose a medium between extremes, and here practice and experience offers a helping hand.

There are different modes of making springs.

Common springs are made of hard drawn steel or gold wire (the latter variety being seldom met with), and the procedure is extremely simple. The wire is wound up and tightened with screws to a form corresponding to the size the spring is intended to have. The spring being tightened down, is subjected to a heat of such a degree as would cause steel to turn blue, after which it will retain its shape; but springs so made are not very durable compared with steel springs hardened in fire, and therefore the latter mode is preferable.

The manipulation is also very simple.

In making a helical spring, the wire is wound upon a hollow cylinder, either quite smooth or furnished with grooves corresponding with the form intended to be given to the spring. The cylinder must never be thicker than about one-eighth of its diameter, because if too thick it will, on being immersed, cool too slowly, to the detriment of the hardness of the spring.

When a smooth cylinder is used, the winding up of the spring is performed in the turns. After one end is fixed to the cylinder by a screw with a flat head, the wire is kept tight by a weight attached to the other end, and wound up till the cylinder is quite full.

Care must be taken that the run of the coils should appear to be even and continuous. So wound up and fixed by screws at either end, it is hardened in a thick iron box with a loose cover; the free space within the box, which ought to be about three times the diameter of the cylinder and somewhat deeper, is then filled with powdered charcoal mixed with some powdered ivory, and the whole is heated to a yellow heat, in which it must be kept about a minute in order that the heat should get well diffused and imparted to the cylinder through the charcoal, which is a bad conductor of heat. Then it should be taken out of the fire and be reversed over a vessel containing oil, the loose top and the cylinder falling into it, and the spring thus becomes hardened. Proceeding thus, the

spring will be evenly hard throughout and never change its form, which sometimes happens when water is used instead of oil. Some makers wrap platina foil round the spring to exclude the air, and then the heating can be performed on a piece of charcoal by means of a blow-pipe. For hardening, cold water must be used in this case. Makers using this mode assert that in consequence of the spring being in contact with metal on each side while being heated and cooled, the granular disturbance within the spring will be less, and a spring so made will soon cease to accelerate its rate, an imperfection to which all springs except very soft ones are more or less subjected. There is a degree of plausibility attached to this argument in favor of this mode. Every maker has his own ideas, but the very fact that amongst a number of springs made by any maker the performance of a few only exceeds the average degree of excellence, proves that assertions of this kind must be received with more or less caution. It is my opinion that the proportion between the degree of hardness and the length of the spring is the principal consideration.

Some makers have the habit of hardening and tempering the spring and then trying whether it will suit the balance, and if the number of turns is between eight and twelve, they use it.

Nothing can be more injudicious than that. He should first make up his mind about the number of turns he wants to employ (I should in no case recommend less than ten), and then temper the spring accordingly. If it does not suit the balance a different wire must be employed, or another spring made with another temper, less coils of course requiring greater hardness.

The great difficulty is that the change of color is scarcely a sufficient guide for the degree of hardness in long springs, for in these low degrees a spring may be made considerably softer without being accompanied with a corresponding change in the color.

A better plan is based upon the fact that a hard piece of steel will color with a smaller amount of heat than a soft one. If two pieces of steel, a hard and a soft one, be put together on a bluing pan, the hard piece will be of a rich blue before the soft one becomes purple, and when a hardened piece which has already been blued twice, after having been whitened after each bluing, is brought to a rich blue color the third time, it will require a degree of heat which would have made it (had it not been whitened twice) of a very pale blue color. As the time when the rich blue color appears can be easily observed, the number of times the operation is repeated will be indicative of the degree of hardness. If a spring having ten coils is blued six times, including the final bluing, it will have a suitable degree of hardness.

It is not necessary that the spring itself should be whitened each time, as the whitening of the screws fastening the wire to the cylinder will serve the same purpose. The spring before being finally blued and set to shape on a cylinder furnished with suitable grooves, must be whitened with oil-stone dust and wood, which is done partly in the turns and partly on a flat piece of wood fixed in a vice, and which is thin enough to go between the coils, to allow the sides or edges to be finished off. The necessary manipulations are so simple as scarcely to need more minute describing. In regard to fixing also, any one having looked at another with any attention can hardly make a mistake.

The curves must be bent with a pair of tweezers kept expressly for that purpose, and to be had at any tool shop.

Flat springs are wound up three at a time between a pair of platina plates, having three steady pins, and being screwed or pinned down to friction tightness, and so hardened.

The best flat springs are, before final bluing, set to shape on a disc having suitable grooves on its plane.

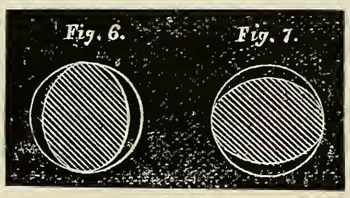
In conclusion, I shall say a few words on the subject of timing watches in positions.

Above all, it is necessary that the frictional conditions in the pivots should be equalized as much as possible, inasmuch as, if too great a difference has to be counterballanced by isochronal adjustments, any change in the extent of the arcs arising out of other than frictional differences (as change in the motive forces while the watch remains in the same position, and imparted motion), will cause the long vibrations to be slower. In order to equalize these frictions it must be increased when in the horizontal and diminished when in the vertical position, as much as possible. In the former case the

flattening of the pivots, or shaping the ends so as to form a slightly-inclined plane (which latter manipulation causes the rubbing surfaces to act farther from the centre), will be necessary. In the latter case, thinness of the holes or a convex shape of the sides of the holes, and utmost finish of the pivots, will be required. The pivots should be conical in shape in order to be made thin without lessening ther durability.

As far as regards the vertical positions, the greatest narrowness of the holes consistent with freedom of motion will be of importance. Very frequently differences arise in consequence of the incorrect form of the pivots. If they are not perfectly round, and are, for instance, of an oval shape, the going of the watch will be influenced in the same manner as if the balance was out of poise.

Figs. 6 and 7 will make that more clear.



There is, of course, always a very small shake in the holes necessary on account of the oil, and when, therefore, such an oval-shaped pivot is in the position indicated by Fig. 6, its centre is farther from the lowest point of the hole than when it is in a position as in Fig. 7, and when the balance vibrates it gives way to the influence of gravity—it *falls* in each half of the vibration; the effect on the rate will be the same as if the balance was bottom heavy. If the long diameter of such a pivot is in a position as in Fig. 7, when the watch is in a quiescent state its effect will be the same as if the balance was top heavy. The existence of such an imperfection can be ascertained by changing the position of the roller or rollers on the balance staff. If the relative points of greatest differences change with the roller, they arise from the escapement; if they retain their position with respect to a given point of the balance, they arise from pivot imperfections, and it is best to change the staff at once. The balance should in all cases be perfectly poised. Any change in this respect is bad.

No other than general rules can be given, as practice and experience are necessary to enable the artist to account for and to correct differences of a more complex nature, because the smaller the error becomes, the more difficult it will be to reduce it, and is much more trying to the reflective powers of the artist than errors of a coarser kind. There is still a wide field to be cultivated by all watchmakers who love their art, and although there are no more Government grants to be won by raising the standard of excellence of time-keepers, the object posseses so much intrinsic interest in itself as always to challenge an honorable ambition of the best in the profession, their exertions being stimulated in addition by the requirements of the present age of railways and telegraphs, where correct time becomes a question of greater importance every day.

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Facing Pinions.

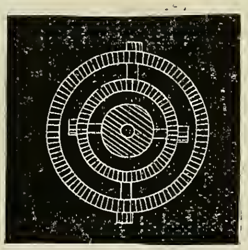
Ed. Horological Journal:

I have been much pleased in reading the series of articles on watch repairing, by Mr. Fricker, which are in the course of publication in the Journal. I am especially pleased with the thoroughness with which the author recommends the various repairs to be executed, and the minuteness of the directions which he gives for doing the work. The remarks on facing pinions, in the January number, are worthy of the serious attention of a large portion of the trade. Although it has no direct bearing on the running of the watch, there is nothing hurts the critical eye more than a badly faced pinion, and more especially if it be in a fine watch where the other pinions are beautifully faced. It is sure evidence of a slovenly workman. The facing of a pinion is but the work of a few minutes to the artist who has his tools and his work-bench properly organized. If we omit the facing of pinions because the customer does not see the work, and if we apply the same principle to all the other repairs of a watch, then there is an end to all pretentions of being fine workmen.

I think, however, that the tool recommended for holding the facers is partly incomplete and might be improved. The manner in which it

is constructed allows the facer to move only in one direction, whereas to be perfect it ought to turn readily in any direction. I am also at a loss to comprehend what benefit would be derived from having a handle to the tool. It seems to me that a handle would make the tool unnecessarily heavy, and render it the more difficult for the workman to communicate that delicacy of touch so necessary in the operation of facing a small pinion. The annexed diagram represents a tool for holding facers which is quite common among the trade in some parts of Europe, and I have also seen it in use in the United States. The diagram will sufficiently explain the points of difference between it and the tool described in the JOURNAL. It is in principle precisely the same as the gimbals of a box chronometer, and allowing the facer to move easily in any direction, and greatly assists the inexperienced in making the work flat.

The tool is composed of two rings, with the facer placed inside of the centre ring. There



are two screws or pivots placed in each ring at right angles from each other. When the tool is used it is held by the outside ring, and any unsteadiness in the workman's hand is not communicated to the facer, because the two rings, with pivots in each at right angles, permit of an easy motion in every direction.

H.

New York City.

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Answers to Correspondents.

B. S., *New Orleans.*—You can resilver the reflecting glasses of quadrants as follows: Place a piece of tin-foil on a perfectly flat piece of board and pour on it a small quantity of as pure mercury as you can get. Then rub the mercury on to the tin-foil with a suitable brush, and it soon unites itself with the tin. The glass which must have been cleaned previously, is then cautiously slid upon the tin leaf in such a manner as to sweep off the redundant mercury which is not incorporated with the tin. A weight is then placed on the glass, and in a little time the quicksilvered tin-foil adheres so firmly to the glass that the weights may be removed without any danger of it falling off. The success of the operation depends much on the cleanliness of the glass, as the least dirt on its surface will prevent the adhesion of the quicksilvered tin-foil.

You can lacquer your nautical instruments by following the directions given for lacquering in the November number of the JOURNAL. The best way to protect iron from rust, is to have it nickel-plated.

R. P., *St. Louis.*—It is an important element in the successful working of a secondary dial to have a constant battery; for although a secondary dial is, in a strict sense, not a clock, but merely an index of the time shown by the primary regulators, yet if the battery is not constant the hands will fail to move regularly. This arises from the fact that the electricity produced by the battery is used for the purpose of giving power to the electro-magnet which moves the hands of the secondary dial. When the current is in the wires the electro-magnet attracts the soft iron armature towards it, and when the current is temporarily interrupted by the primary regulator the power of the electro-magnet ceases, and the spring pulls the armature back to its original position. These motions of the armature backward and forward at stated intervals are the means by which the motion of the hands is produced. If the action of the battery varies, and more or less electricity is produced, the power of the electro-magnet will be proportionably stronger or weaker. If the electro-magnet be too weak for the strength of the armature spring no motion will follow; if it be too strong, the result will be the same. There must be a certain equilibrium between the strength of the armature spring and the power of the magnet. Hence the necessity for a battery that will be constant in its action under every variety of circumstances, and it must not be used for any other purpose when it is in connection with the clock. You will require a separate battery for electro-plating, even although you have but little of it to do.

M. T., *Vermont.*—You could have got the length of the top pivot, even though you had "forgotten to measure it before embedding it in wax on the lathe." Take your balance off the staff, lay the cock upon it with a bit of card or thick paper between, just thick enough to give it the proper freedom from the cock. Then with your Swiss gauge measure from the underside of the balance-arm to the top of the hole jewel, which will be, say 10.75°; then turn away the cement till you come to the shoulder upon which the balance rests, 19.75° measured off from that shoulder on your inserted pivot will be the point of proper length. It is always best to have your work a little full of the measurements, for it is far easier to finish down to fit than to be obliged to reconstruct, because too short or too small.

M. A. N., *Texas.*—The *tourbillon* which you speak of as an escapement, you misapprehend; it is simply a mechanical arrangement by which the whole escapement, whatever kind it be, whether lever, chronometer, duplex, or other, is revolved about itself once a minute. This is designed to obviate the necessity for adjusting to position, for the balance has each point of its whole circumference constantly changing its position, that is, it takes a new position, as regards up and down, at every instant. The tourbillon frame which contains the escape-wheel, lever, and balance, is driven by the third wheel of the train. What would be the fourth wheel is fixed by its rim to the great frame a little above it, the tourbillon arbor going quite through them; the pinion of the escape-wheel rides around the fixed wheel like a "planet," as the tourbillon revolves; this is the same as if the fixed wheel revolved and the frame stood still, except that the escape-wheel makes one more revolution for every turn of the tourbillon, or as if the number of the fourth wheel teeth were increased by the number of the escape-wheel pinion. The arrangement is complicated, expensive to construct, and of very doubtful practical utility.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For April, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be added to / subtracted from Apparent Time.	Diff. for One Hour.
		s.	M. S.	s.
Tuesday	1	64.51	3 51.94	0.754
Wednesday	2	64.53	3 33 91	0.749
Thursday	3	64.55	3 15.98	0 744
Friday	4	64.57	2 58.19	0 739
Saturday	5	64.60	2 40.56	0.732
Sunday	6	64.63	2 23.10	0 725
Monday	7	64.66	2 5.82	0 716
Tuesday	8	64.69	1 48.76	0 707
Wednesday	9	64.73	1 31.95	0.696
Thursday	10	64.77	1 15.38	0.686
Friday	11	64.81	0 59.07	0.674
Saturday	12	64.85	0 43.05	0.661
Sunday	13	64.90	0 27.35	0.647
Monday	14	64.95	0 11.98	0.633
Tuesday	15	65.00	0 3.04	0.618
Wednesday	16	65.06	0 17.71	0.603
Thursday	17	65.11	0 31.97	0.586
Friday	18	65 17	0 45.83	0.569
Saturday	19	65.23	0 59.28	0.551
Sunday	20	65.29	1 12.31	0.533
Monday	21	65 35	1 24.89	0.514
Tuesday	22	65.42	1 37.00	0.495
Wednesday	23	65.49	1 48.64	0 475
Thursday	24	65.56	1 59 80	0.455
Friday	25	65.63	2 10 48	0.434
Saturday	26	65.70	2 20.66	0.413
Sunday	27	65 77	2 30.34	0.392
Monday	28	65.85	2 39 52	0.371
Tuesday	29	65.92	2 48.19	0.350
Wednesday	30	66.00	2 56.35	0.329

Mean time of the Semidiameter passing may be found by subtracting 0s.18. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D.	H.	M.
☽	First Quarter	4	6	36 0
☉	Full Moon	12	9	51.4
☾	Last Quarter	19	17	47.8
●	New Moon	26	10	42 6

		D.	H.
☾	Apogee	7	11.3
☾	Perigee	23	7.6

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION. D. H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus	1 3 5 34.12	+23 21 30 1	2 25 7
Jupiter	1 9 38 29.86	+15 20 18.6	8 57 3
Saturn	1 20 14 42.54	− 20 0 11.0	19 32.1

AMERICAN

Horological Journal.

VOL. IV. NEW YORK, APRIL, 1873. No. 10.

CONTENTS.

ESSAY

ON

WATCHMAKERS' REGULATORS, WITH PRACTICAL DETAILS FOR THEIR CONSTRUCTION.

BY HENRY J. N. SMITH.

CHAPTER III.

ARRANGING THE MOVEMENT.

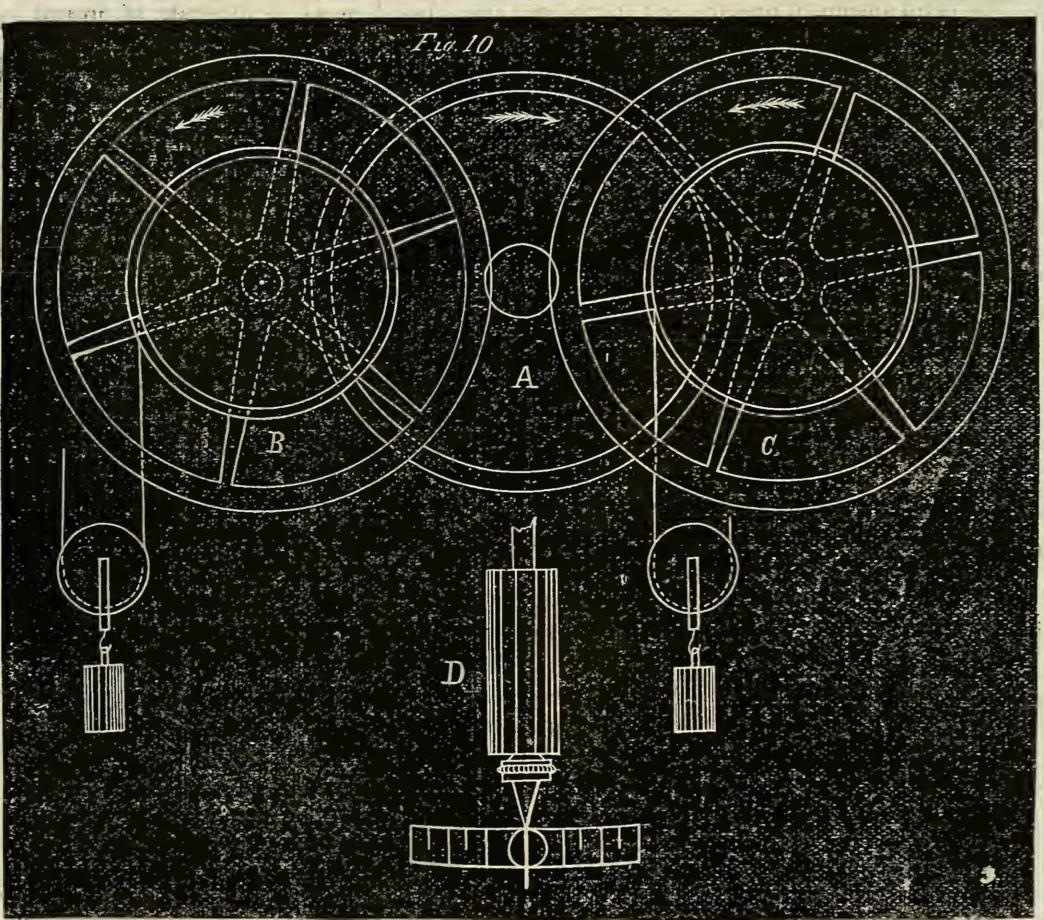
In the two preceding chapters the various plans usually employed for constructing a regulator, the style of the dial, the motive power, the period for winding, the escapement, the length of the pendulum, and other fundamental points having been variously discussed, I will first proceed with the practical details for constructing a regulator movement with a Graham or dead beat escapement, and afterwards point out in what respect the movement has to be made different to suit the requirements of the various forms of gravity escapements.

The arrangement of the mechanism of an ordinary regulator is a simple operation compared with some other horological instruments of a more complex character. We are not prescribed for room to the same extent as in a watch, and the parts being few in number a regulator is more easily planned than timekeepers having striking or automatic mechanism for other purposes combined with them; yet it often happens that the inexperienced make serious blunders in planning a regulator, and, as the clock approaches completion, many errors make themselves visible, which might have been avoided by the exercise of a little more forethought. It may be that, when the dial is being engraved, the circles do not come in the right position, or the weight comes into too close proximity with the pendulum or the case, or the cord comes against a pillar, or other faults of greater or less importance appear, all of which might have been obviated by taking a more comprehensive view of the subject before beginning to make the clock.

POSITION OF THE BARREL.

The position which the barrel and great wheel should occupy, is worthy of serious consideration. In most of the cheap class of regulators, as well as in a few of a more expensive

order, the barrel is placed in a direct line below the centre wheel, as is shown in Figure 9. This arrangement admits of a very compact movement, and it also allows the weight to hang exactly in the centre of the case, which some think looks better than when it hangs at the side, especially when there is a glass door in the body of the case. But while a weight hanging in the centre of a case may be more pleasing to the eye than when it hangs at the side. I consider this an instance where looks can, with great propriety, be sacrificed for utility, because when the weight hangs in the centre it comes into too close proximity with the pendulum, and is very liable to disturb its motion. In proof of this statement, let any reader who has a regulator with a light pendulum and a comparatively large weight hanging in front of it, closely watch the length of the arc the pendulum vibrates when the weight is newly wound up and when it is down opposite the pendulum ball, and he will observe that the arc



of vibration of the pendulum varies from five to fifteen minutes according to the position in which the weight is placed; that the pendulum will vibrate larger arcs when the weight is above or below the ball than when it is opposite it; and if the clock has a tendency to stop from any cause, that it will generally do so more readily when the weight is opposite the pendulum ball than when it is in any other position. For this reason I would dispense with the symmetrical looks of the weight hanging in the centre of the case, which, after all, is only a matter of taste, and construct the movement so that the weight will hang at the side, and as far away from the pendulum as possible.

Fig. 10 is intended to represent the effect placing the barrel at the side has on throwing the weight away from the pendulum. A is the centre wheel, and B and C are the great wheels and barrels with weights hanging from them, and D is the pendulum. It will be noticed by the diagram that the weight at the

left of the pendulum is exactly the diameter of the barrel farther away from the pendulum than the weight on the right. On close inspection it will also be observed, that on the barrel C the force of the weight is applied between the axis of the barrel and the teeth of the wheel, while on the barrel B the axis of the barrel lies between the point where the force is applied and the point where the teeth act on the pinion; consequently a little more of the effective force of the weight is consumed by the extra amount of pressure and friction on the pivots of the barrel B than there is in C.

Notwithstanding this disadvantage, I would for a regulator recommend the barrel to be placed at the left side of the centre wheel, because the weight may thereby be led a sufficient distance from the pendulum in a simple manner. If we place the barrel at the right, and thereby secure the greatest effective force of the weight, and then lead the weight to the side by a pulley, we will lose a great deal more by the friction of the pivots of the pulley than we gain by the proper application of the weight. In fuzee watches, or even in large tower clocks, placed in cramped positions, and where there is only a limited amount of power available, it may be very proper and very desirable to arrange the mechanism so that the cord or chain will come between the barrel or fuzee and the centre pinion, and thereby use all the force of the weight or the spring in the most effective manner.

In a regulator with a Graham escapement, however, but little force is required to keep it going, and there is usually accommodation for an abundance of power therefore I think that we cannot use a little of this superabundant available force to better advantage than by placing the barrel at the left side of the clock, and thereby throw the weight a sufficient distance from the pendulum in the simplest manner.

NUMBER OF LEAVES IN THE PINIONS.

Like the action of the escapement, I think that the practical value of making pinions with very high numbers is very much overrated. I know of two clocks situated in the same building that are compared every other day by transit observation. They have both Graham escapements and mercurial pendulums, and are equally well fitted up, and as far as the eye can detect, they are about equally well made in all the essential points, with only this difference: one clock has pinions of eight, and the other pinions of sixteen leaves, yet for two years one clock run about equally as well as the other. In fact, if there was any difference, it was in favor of the clock with the eight-leaved pinions. In giving this example, I must not be understood to be placing little value on high-numbered pinions. I know that in some instances they can be used to advantage. The idea that I want to illustrate at present is, that it is not in this direction that we are to search for the means of improving the rates of regulators.

A pinion as low as eleven leaves can be made so that the action of the tooth will begin at or beyond the line of centres; but as eleven is an inconvenient number to use in clock-work, we may with great propriety decide upon twelve as being a sufficient number of leaves for all the pinions used in a regulator having a Graham escapement.

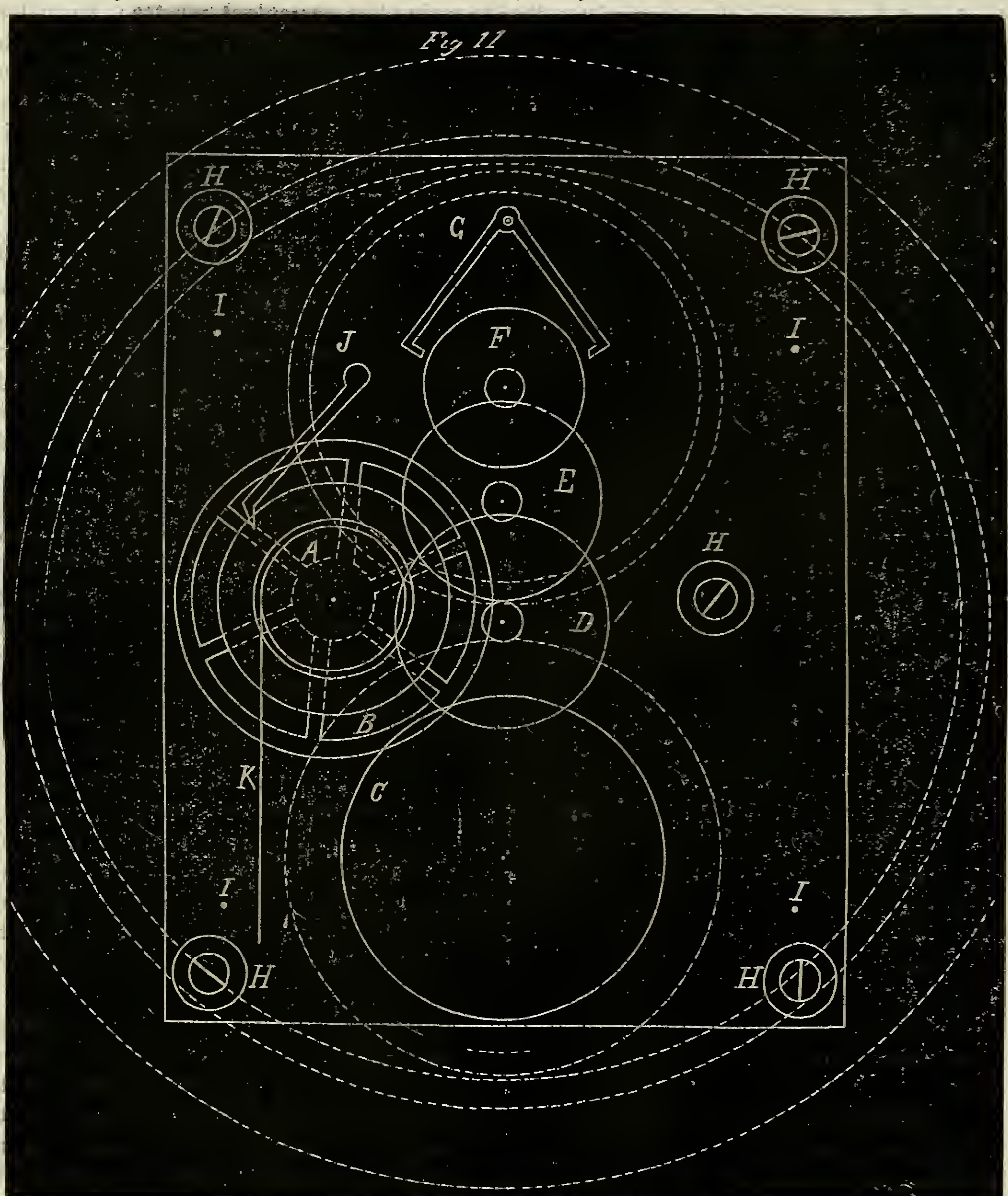
SIZE OF THE WHEELS.

The wheels in regulators are, I think, sometimes made larger than is desirable. There is no benefit derived from making wheels larger than is necessary, but, on the contrary, there are several disadvantages. Within certain limits large wheels are more difficult to make accurate than smaller ones are. They also require a greater amount of force to move them; the effects of leverage are greater, and being heavier they cause a greater amount of friction on their pivots than smaller and lighter wheels, and for these reasons none of the wheels should be made any larger than is absolutely necessary to secure sufficient strength for the teeth, or to raise the pinion they drive to the desired distance from the centre of the wheel.

In arranging the size of the wheels in a regulator, the diameters of the centre and third wheels are determined by the distance between the centre of the minute and the centre of the seconds hand circle on the dial. As the dials of regulators are usually engraved after the dial plates have been fitted, and as the position of the holes in the dial for the centre and scape wheel pivots to come through determines the size of the seconds circle, it may be well to mention here that, for a twelve-inch dial, two and a half inches is a good distance for the cen-

tre of the minute circle to be from the centre of the seconds circle. Consequently the centre and third wheels must be made of such a diameter as will raise the scape wheel axis two and a half inches from the centre wheel axis, and the other wheels must be made proportionably larger, according to the number of teeth they contain.

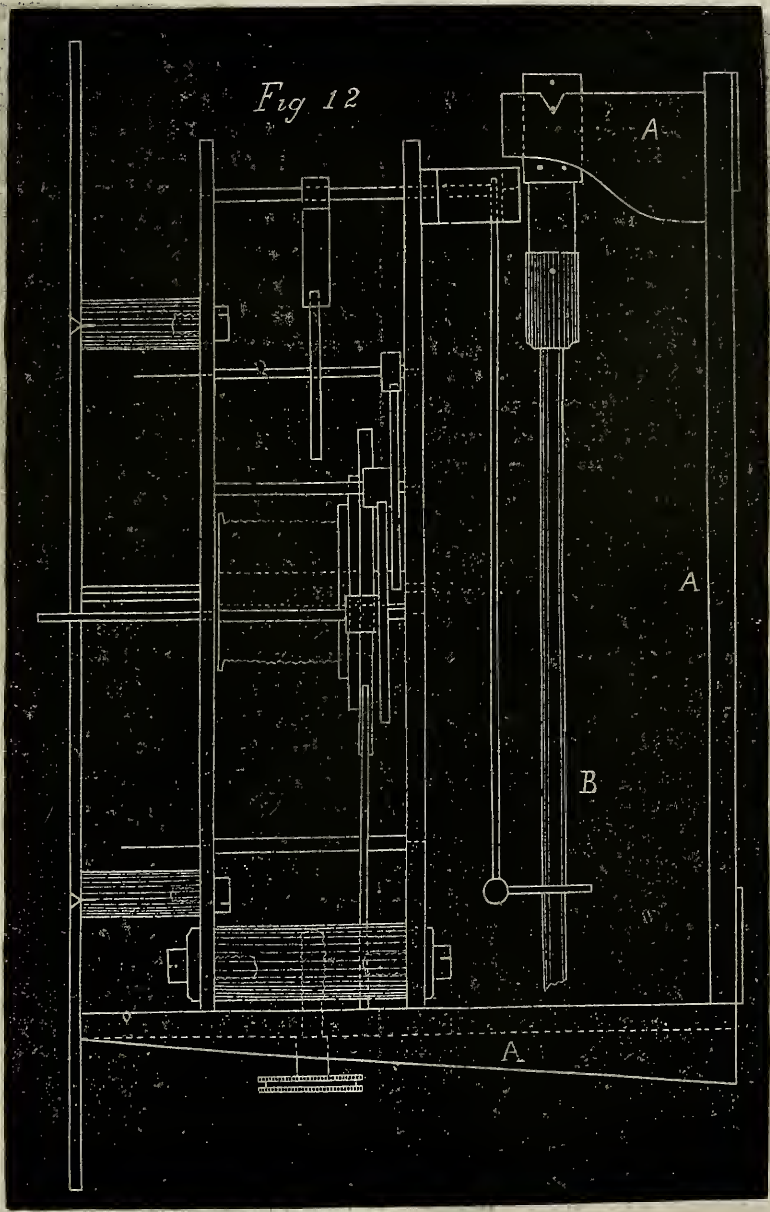
We all know what a difficult matter it is to make a cutter that will cut a tooth of the proper shape; but when the cutter is once made and carefully used, we also know that it will cut or finish a great number of wheels without injury. For this reason, those who are contemplating making only one, or at most but a few



regulators, will find the work will be greatly simplified by making the wheels of a diameter proportionate to the number of teeth they contain, and for all practical purposes the cutter that cuts or finishes the teeth of one wheel will be sufficiently accurate for the others. If we make all the pinions with the same number of leaves they will also all be nearly of the same diameter, and may be cut, or rather the cutting operation may without any great impropriety be finished with one cutter.

An opinion prevails among a certain class of

workmen that the teeth of the great wheel and leaves of the centre pinion should be made larger and stronger than the other wheels and pinions, because there is a greater strain upon them than on the others. However reasonable this idea may seem, a little consideration will show that in the case of a regulator, with a Graham escapement, where so little motive power is required to keep it in motion, an arrangement of this nature is altogether unnecessary. The smallest teeth ever used in any class of regulators are strong enough for the great wheel; and if there be a greater amount of strain on the teeth of the great



wheel in comparison with the teeth of the third wheel, for example, then make the great wheel itself proportionably thicker, as is usually done, according to the extra amount of strain that it is to bear. The teeth of wheels and the leaves of pinions wear more from imperfect construction than from any want of a sufficient amount of metal in them.

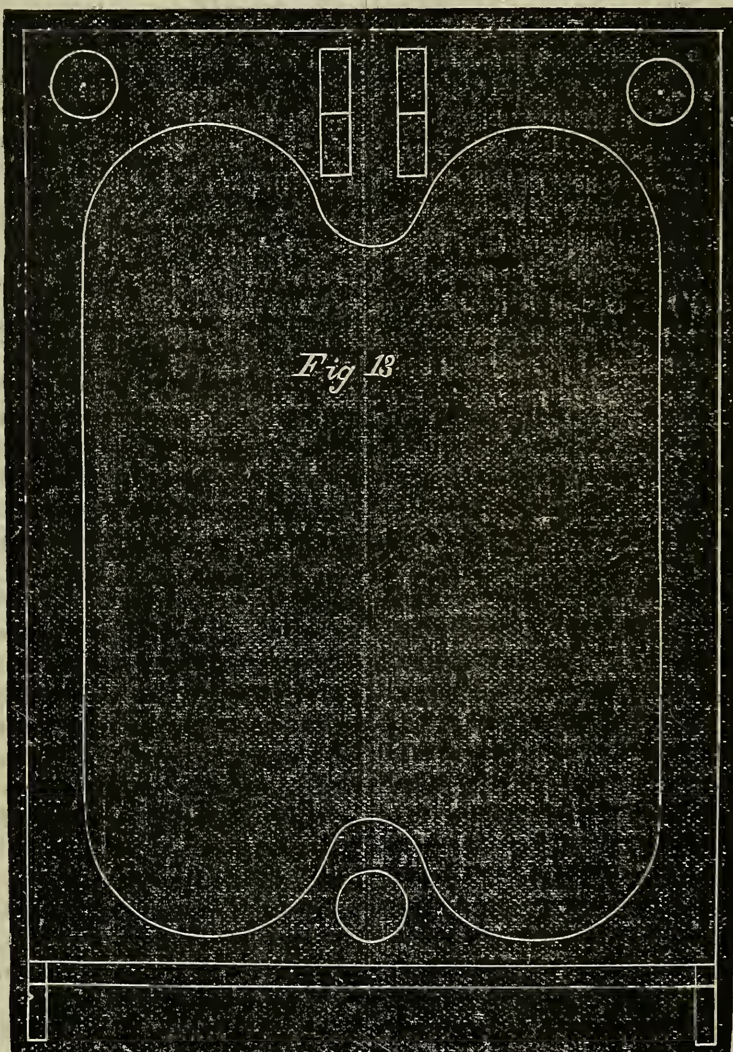
If we assume the distance between the centre of the minute and the centre of the seconds circle to be 2½ inches, and also assume that the clock will have a seconds

pendulum, and all the pinions have 12 leaves, and the barrel make one turn in 12 hours, then the following is the diameter the wheels will require to be, so that the teeth may all be cut with one cutter, and also the mumber of teeth for each wheel:—

Great Wheel	144 Teeth.		Diameter	3.40	inches.
Hour	"	144	"	3.40	"
Centre	"	96	"	2.26	"
Third	"	90	"	2.11	"
Scape	"	30	"	1.75	"

POSITION OF THE WHEELS, ETC.

Figure 11 is a front view of the proposed regulator movement, showing the size and position of the wheels, the size of the frames, the position of the pillars, dial feet, etc. This diagram, as well as Figures 12 and 13, are drawn on a seale exactly one-half the full size. The dotted large circular lines on Figure 11 show the position the hour, minutes, and seconds circle will occupy on a dial fitted to a



movement made from this caliper. According to the ordinary rules of drawing, the dotted lines would infer that the movement is in front of the dial, and perhaps it may be necessary to explain that in the present instance these lines are made dotted solely with the view of making the diagram more distinct, and are not intended to represent the dial to be at the back of the movement. A is the barrel, B is the great wheel, which turns once in twelve hours; C is the hour wheel, which works into the great wheel, and also turns once in twelve hours; D is the centre wheel, which turns once in an hour, and carries the minute hand; E is

the third wheel, and F is the scape wheel, which turns once in a minute, and carries the seconds hand; G is the pallets; H, H, H, H, H, the pillars; and I, I, I, I, are the dial feet; J is the maintaining power click, and K shows the position of the cord. Neither the hour or great wheels project over the edge of the frame, and it will be observed that a clock of this arrangement is remarkable for its simplicity, having only four wheels and three pinions, with the addition of the scape wheel and the barrel ratchets. There are no motion or dial wheels, the wheel C turning once in 12 hours, carrying the hour hand. The size and shape of the frames, and the position of the pillars, allows the dial feet to be placed so that the screws which hold the dial will appear in symmetrical positions on the dial. A movement made on this plan will admit of a dial either of the form of Figure 3 or Figure 4, as the taste of the maker prefers.

METHOD OF FASTENING THE MOVEMENT IN THE CASE.

Fig. 12 gives a side view of the proposed clock. A A A is a metal bracket which the clock movement rests on, and from which the pendulum B is suspended. This plan is, beyond all question, the best that has yet been devised for fitting a fine clock in a wooden case. It provides a firm support for the pendulum, and also admits of the clock being cleaned without removing the pendulum, which, in some forms of compensation, is itself a great object.

This bracket may be made of cast iron, and the drawing is on a scale one-half the full size. The length of the lower part of the bracket, and that part of it from which the pendulum is suspended, must be determined by the depth of the regulator case; but as cases are usually made, the drawing is exactly half the required size. Fig. 13 shows a front view of the back part of the bracket. In the diagram it is cut out in the centre to secure lightness, and the three small circles indicate the position of the screws or bolts that fasten the bracket to the case. Two bolts are placed at the top of the bracket, near where the pendulum is suspended, and one at the bottom, which will be found to be sufficient for every purpose. Although the back part of the bracket is cut out to insure lightness, the bottom part, on which the movement rests, is intended to be cast thin but solid, with two thin pieces on its edge, tapering from the back to the front, to secure strength. The reason for the bottom part being cast solid is to prevent dust from reaching the movement from the bottom, for all the space round the movement between the back of the case and the back of the dial will, when the regulator is finished, also be covered in to protect the movement from dust in the most effectual manner.

The pattern for the bracket should be made so that it can be cast all in one piece; and as there are always pattern-makers in connection with every iron foundry, this will be no great trouble or expense, if the maker of the clock cannot procure a casting ready made.

[TO BE CONTINUED.]

The Formation and Angles of Tools.

BY PROF. T. EGLESTON, SCHOOL OF MINES, N. Y.

How to make and keep tools in order, is one of the most important questions a mechanic has to answer. In order to contribute somewhat to the solution of this question, the following paper has been prepared. Originality in it is not claimed. Most of the investigations and observations recorded are published in papers by Holtzapffel, Willis, Babbage, Naysmith, and others (the investigators' own words being very often quoted in this paper); but they are not easily accessible, and besides this, no one or two papers embrace what is known on the subject. It is hoped that this article may awaken some interest, and perhaps help to solve some of the difficult problems which occur every day in a workman's experience.

There is no process requiring the use of cutting tools which is accomplished with the facility, rapidity, and precision of turning, because the work and the tools are guided; the work revolving between fixed centres, and the tool guided either by the hand or a fixture made for the purpose. But the best lathe can do no more than place the work in the most favorable position. It is but a poor machine, however elaborate and costly it may be, if the tools which are used with it are either badly made or badly applied to the work. Its efficiency depends entirely on the proper

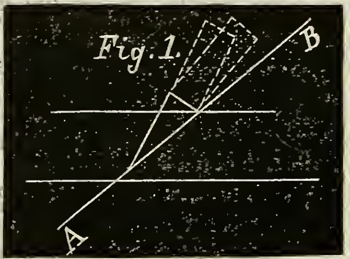
angles being given to the tools, and their proper application.

It is not sufficient that the mechanic should have good tools. A knowledge of the principles upon which they are formed, and of the proper methods of guiding them, is essential to his success. Every mechanic can make his own tools, which means that he purchases them more or less roughly formed, and grinds them to the proper angle. The methods of grinding are generally learned by long experience, and the knowledge highly valued; but in practice there are many forms of tools which are only accidentally good, and therefore must be considered as empirical forms, for which others might with advantage be substituted, if the principles of the formation of tools were rightly understood. A good workman may use a badly ground tool, because experience has taught how to hold it to make it cut; that is, how to hold it in such a way that it shall form the proper angles with the surface upon which it is to act. This is, however, a *tour de force*, and may therefore be considered almost in the light of an obstacle to progress, since it requires great experience, and but few persons can acquire the art. The tool is, or should be, the servant of the workman; but, in general, where empirical rules are used, it is rather his master than his assistant.

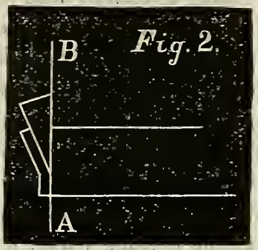
Whatever may be the form or purpose of any tool, its proper service will depend on the way in which its edge is applied to the surface to be acted upon. We say edge, because, though tools are often pointed, if the extremity of the point is carefully examined it will generally be found to be terminated by a very minute edge; or, if really a point, the acting surface will be found to be an edge near the point, and not the point itself. As tools are not made with obtuse cutting edges, the consideration of the principles of the formation of tools will be the discussion of the laws which govern the action of acute edges in general, without reference to any particular form or application of the tool. Every cutting edge is a wedge, so that in discussing the angles of tools we shall be treating the subject of acute angled wedges.

Every tool edge can affect the surface upon which it acts in two different ways. It may *cut* or *scrape* it. There are two other effects, apparently very different from these, well known to every mechanic, and these are *digging* and *chattering*. *Digging* is only an intensified cutting, owing to a badly formed tool, or the improper application of a good one. *Chattering* is an intermediate stage of scraping. Both of these effects are fatal to good work, but do not, however, require special attention, since the proper understanding of the principles of *cutting* and *scraping* will prevent them altogether. *Cutting* may be said to be the use of the tool in such a way as to *cause* the edge to *penetrate*, and *scraping* its use in such a way that it *cannot penetrate*. We shall, therefore, be mainly occupied with the principles which cause tools to penetrate.

As we have said above, every cutting edge is simply a wedge, whose edge is formed at such an angle that, by the aid of the power applied behind it, it can penetrate into the substance acted upon. The comparative amount of opposition which a face of the tool receives, the hardness of the substances acted on not being taken into the consideration, will depend either on the amount of surface in contact, as in Fig. 1, or on the material giving way on one



side, as in Fig. 2. It will be seen, in Fig. 1, that the action of the wedge is the same, whether it is made with one or two bevels. This is the general action of wood tools. Fig. 2 shows the action of paring tools, to which class lathe tools belong.



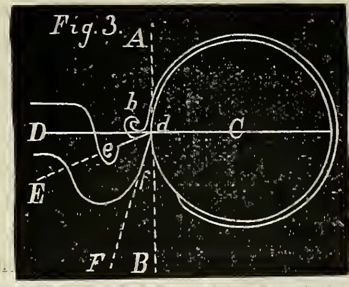
Tools are usually applied so that the pressure is greater on one edge than another, and the edge where the pressure is greatest will, in all cases, guide the course of the work. This edge

will always be the face next the surface of the work, as A B, Figs. 1 and 2. The first step, therefore, and the most important one, is so to place the lower face of the cutting edge that it shall be *in a line with the direction the cut is intended to follow.* The whole edge is thus placed in its natural position as a wedge. When the tool is made to take any other position, it will assert itself at once either by *digging* or *chattering.* This is true only of tools whose thickness is not appreciable. The moment this element is taken into account we shall find the progress of the tool opposed by friction, because the face of the edge will rub against the work. To prevent this as much as possible, the face below the cutting edge must be slightly bevelled. This bevel Babbage calls the *angle of relief*, and should generally be very small. Its minimum is 3°, and its maximum may be considered as 6°. This angle, in all circular work, is estimated from the tangent to the circumference at the point where the tool acts. Thus, in Figs. 3, 4, 5, 6, and 7, the line A B is the tangent to the circle at this point. The angle included between A B and the lower plane of the tool is the *angle of relief.*

Before deciding upon the forms of different tools, it is necessary to discuss the principles on which their cutting edges act, in order to ascertain how they produce their effect, and to determine what are the most suitable angles to be used under different circumstances, and with different methods. These principles are best illustrated by selecting the principles of action of slide rest tools, because the tool is here in a fixed position, which is the theoretical position of all tools. The proper use of hand tools follows necessarily from the use of slide rest tools. We shall therefore divide the subject into—

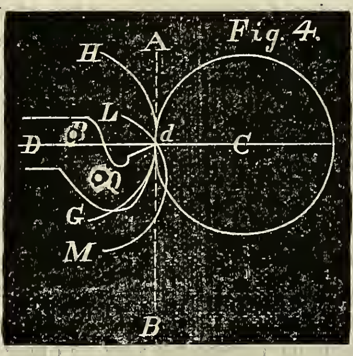
1. *The principles which govern the formation of slide rest tools so as to get the best work with the least expenditure of time and force.*
2. *Conditions necessary to secure and retain the best action of cutting edges.*
3. *Edges most suitable for different materials.*

A slide rest tool, acting on a cylinder as at *d*, Fig. 3, removes from it a shaving. In order to determine on what principle this is done, we must give names to certain points and angles of the tools. D *d* C is a straight line passing



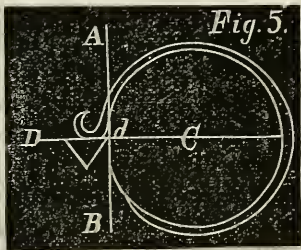
through the point acted upon, and the centre of the circle; E *e d* is a line passing over the cutting point of the tool, and through the point acted upon, *d*. A B is the tangent to the circle at the point *d*. These lines form with each other a number of angles of importance, to which the following names have been given: The angle B *d* F is called the *angle of relief;* F *d* E the *angle of the tool, or the section angle of the tool;* E *d* D the *angle of escape.*

The angle of relief should always be very small, because the point of the tool, *d*, will, in that case, have its support nearly in a line opposite to the force acting upon it. This depends on the angle which the upper surface of the edge makes with the surface of the work. Whatever the shape of the particular edge may be, this angle is reduced to a minimum by keeping the lower face as close as possible to the surface being acted upon. Whenever acuteness

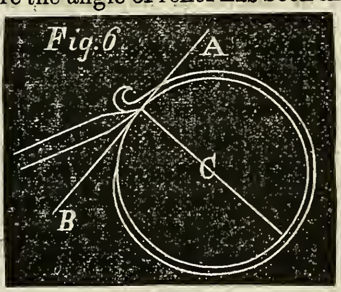


is required in a cutting edge it must be obtained from the upper surface, and not by increasing the angle of relief. This is shown in Figs. 3, 4 and 6, which represent tools for iron and wood, the angle of relief being exactly the same in both cases. A most important reason for keeping this angle as small as possible is the strain required to remove the shaving. This strain falls in the direction of the diameter,

and may therefore be estimated from the tangent at the point of contact of the tool. This



is illustrated in Figs. 3, 4 and 5, where all the cutting edges are 60°. In Figs. 3 and 4 the angle of relief is 3°; the shaving will consequently be wedged off at an angle (E *d* B, Fig. 3) of 63°, which is the smallest possible angle. In Fig. 5, where the tool is also 60°, but where the angle of relief has been increased,



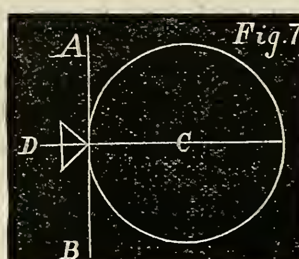
the angle of wedging off, D *d* B, is increased to 90°. The tool here might better have been 87°, 3° being deducted for the angle of relief. This more obtuse angle would work better than the acuter one, because in Fig. 5 the edge of the tool points into the work and has a tendency to dig. Thus a change in the angle of relief, Fig. 5, increases the amount of strain on an edge which is less able to bear it than that of Figs. 3 and 4, for in the latter case the strain makes a small angle with the edge, while in the former it makes a right angle, following directly across it, rendering it much more liable to abrasion and fracture. The *cutting* action of an edge is, therefore, most favorably situated when its lower face is as near the surface to be acted upon as practicable; or, in other words, when it occupies very nearly the position of a tangent at that point, Figs. 3, 4 and 6. The tendency to *penetration* will therefore be most effectually prevented if a line at right angles to the tangent at the point of action (the radius of the circle produced) bisects the cutting-edge, as in Fig. 7, and this, therefore, will be the position of all *scraping* tools, whatever their angle may be.

The most common illustrations of these principles are the razor and the ink eraser. The razor is a cutting tool, and if the edge is placed against the face with the back slightly raised, so as to give the proper angle of relief, it will cut the beard, but in any other position it will dig into the skin. The ink eraser is a scraping tool. If its edge is not held perpendicularly to the paper, it will dig into it and either cut or tear it.

If a turning or planing tool is improperly made, or presented to the work in such a way that it has a tendency to dig, a very small angle of relief and a long back (*f d*, Fig. 3), will have a tendency to counteract it. The smaller the angle of the tool (E *d* F, Fig. 3), the less the force required for its use. This advantage is, however, counterbalanced, when the angle is very small, by a weakness in the cutting point. There is another disadvantage in making the angle of the tool smaller than the escape of the shaving requires, and that is, that if the mass of metal with which the point is in contact is smaller, the heat acquired in the operation will not so quickly be got rid of.

The angle of escape (E *d* D, Fig 3) is of the greatest importance, varying with the nature of the materials being acted upon. If the angle is very small, the action of the tool is rather that of scraping than of cutting, and the matter removed is more like powder, unless the material is very flexible and cohesive.

Fig. 5 may represent one edge of the old-fashioned drill, which is bevelled on the under side, having the upper face perpendicular to the surface of the work. The less acute the edges



of the drills of this kind are made, the smoother they will cut; for so long as the upper surface is at right angles to the work, increasing the angle of relief only increases the force required to wedge back the shaving, and at the same time the tendency to dig. When the cutting edges of such drills are required to be very

acute, they should be hollowed out so as to give the necessary acuteness to the upper face. The *twist drill* is the best example of a drill made on proper principles, for while the proper angle is preserved on its face, the spiral flutes give the necessary acute angle for the upper surface. All bow drills, whose edges are ground on both sides, and consequently act in both directions, are made on the principle of Fig. 7, and their action is one of scraping, and not of cutting.

In slide rest tools, when the sense of touch is not available for adapting the tool to the proper position, the most accurate adjustment is required before commencing the work. The slide rest generally allows motions only in two

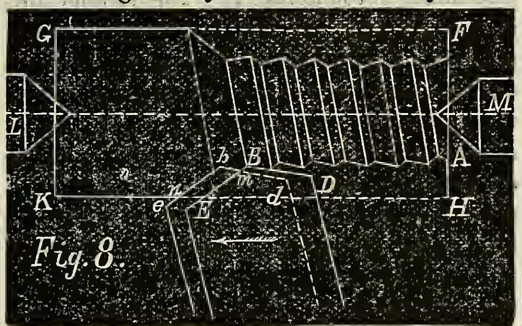


Fig. 8.

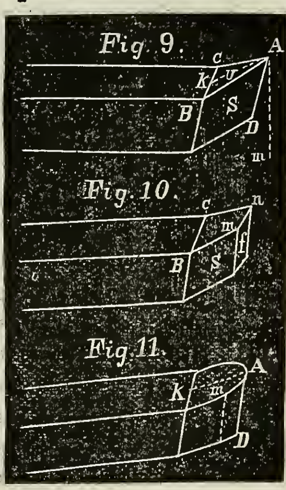
parallel planes; the edge of the tool must be applied to the work in a plane passing through the centres of the lathe, and parallel to the planes of the slide rest. If we suppose a slide rest tool to be placed in the position of the wood-turning tool, as in Fig. 6, if a cylinder was being turned the tool would very soon pass entirely over it without touching it, or if a face was being turned, a large core would be left. The general position on a line with the centres is, therefore, the only one which is suitable to all positions of fixed tools.

Let F S H K, Fig. 8, represent a cylinder of metal—between the centres of the lathe, subjected to the action of a slide rest tool, D B E. The tool is supposed to have passed from A to B, for the purpose of turning a cylinder, and to be fixed in the slide rest so as to move in a direction parallel to the axis of the work, being carried forward at such a rate that the point B moves uniformly the distance B *b* at every revolution of the cylinder. The effect of the movement will be to trace a screw thread on the surface of the cylinder, which, in the drawing, is very much exaggerated. It appears generally as a mere roughness. D B E and *d b e* represent the position of the tool at the commencement and end of one rotation The space between them, *m b n*, will, therefore, represent the section of the first shaving which runs off during the process of turning. In the drawing, *b n* is the width of the shaving, and *b m* its thickness ; but by varying the angle and the rate of the movement of the tool, this may be reversed. In all cases, however, with a tool at this angle, two cutting edges are used in detaching the shaving ; B E representing the width, and D B the thickness of the shaving, or *vice versa*.

In adjusting the position and angles of a tool for turning or planing, it is essential that its action should have been previously studied. If in practice a tool was in the position Fig. 8, the motion would be slow, and the space B *b* or *m b*, which is the thickness of the shaving, would be much less than in the figure. It is generally supposed that B E alone is the cutting edge, and that the shaving would come off without the assistance of the other edge D B. The edge B D is the only one which is left to act on the surface of the work ; and if the shaving is torn off edgewise, by a single-acting tool so constructed that this force does not act, the surface of the work will necessarily be left rough. By placing the edge even parallel to the axis of the work, and rounding the corner D, and carefully sharpening the edge B D, the spiral on the surface of the cylinder may be entirely obliterated, and a finished surface left. The action of the two edges is therefore different ; B E penetrates and separates the breadth of the shaving, leaving a rough surface, which at the next revolution is obliterated by the edge D B. The first edge therefore does the roughing, and the second the finishing work.

Fig. 9 shows the simplest form of tool, in which AB and A C are the cutting edges. The stem of the tool may be of any shape which convenience or fancy may require, but the cutting portion must be bounded by three planes—two *side* planes, S, only one of which is seen in the figure, and an *upper* plane, U. The intersection of the *upper* plane with the two *side* planes produces the cutting edges A B and A C, and the intersection of the two *side* planes produces the angle B C A, which is called the *plan angle of the tool.* It is by the proper inclination of these planes to each other that we obtain the necessary acuteness of the cutting edges, and the de-

sired form of the point. The plan angle is formed by the two planes S, and determines the form of the point of the tool, and the section of



the shaving. A greater or less inclination of the upper plane U, if the tool rests in a horizontal bed, produces a greater or less acuteness in the cutting edges. If the upper plane is horizontal, the cutting edges will be 90°, whatever be the plan angle of the tool. If it is not, then the angle of the edges will vary with the plan angle and the inclination of the upper plane.

Different metals and different qualities of the same metal require different angles, which have been more or less exactly determined by experiment. It is generally admitted that wrought iron and steel require an angle of 60°, cast iron 78°; that brass may be roughened at 80° and finished at 90°. The angles for iron and steel are thus admitted as being those of a tetrahedron, while those for brass are the angles of a cube. A variation of a degree or two in these angles will probably be of little consequence; but as some kinds of work require that it should be finished with the same tool with which it is commenced, without requiring grinding, however long the time may be, it is important to study the angles of the edges.

In grinding a tool it is convenient to consider only the angle which the upper plane U makes with the front line of the plan angle A D. The angles of the cutting edges A B and A C are equal. If we suppose a vertical plane to pass through A D, and making equal angles with the side planes S, it will intersect the upper plane in a line A *k*, bisecting the angle B A C, and the upper plane will be perpendicular to this vertical plane. We thus have a measure of the angle *k* A D. A rough goniometer will enable us to grind this upper plane at any angle *k* A D, and thus insure the cutting edges being alike. This angle, *k* A D, is the *angle of the tool or section angle*, and is not the same as that of the cutting edges. The question to be answered in every case is: Given the plan angle of the tool, and the cutting edge required for the metal to be treated, to find the angle *k* A D of the upper plane. This can only be done by a trigonometrical calculation, the result of which has been given in a table published by Willis. It has not been considered necessary to give the angles nearer than half a degree, which is indicated by decimal; thus 69° 30′ is written 69°.5.

Table of the Section Angles *k* A D.

PLAN ANGLE UPON A D.	CUTTING EDGES.								
	85°	80°	75°	70°	65°	60°	55°	50°	45°
150°	....	80.	74 5	69 5	64.	59.	54.	48.5	43.
140°	....	79.5	74.	69.	63.	58.	52.5	47.	41.5
130°	....	79.	73 5	68.	62.	56 5	51.	45.	39.
120°	84 5	78 5	72 5	67.	60.5	55.	49.	42.	35 5
110°	84.	78.	71.5	65 5	59.	52.5	46.	38 5	30.
100°	83.5	77.	70.	63.5	56.5	49.5	42.	33.	23.
90°	83.	76.	68 5	61.	53.	45.	36.	25.	0.
80°	82.	74 5	66.	58.	49.	39.	27.	0.	....
70°	81.	72 5	63.	53.5	42.	29.	0	....	....
60°	80.	70.	58 5	47.	33.	0	....	....	....
50°	78.	66.	52.	36.	0	....	....	....	....
40°	75.	59 5	40.	0	....	....	....	....	....

To use this table, the column giving the cutting edges is first consulted. Opposite to the column headed plan angle of the tool, the inclination of the upper plane or the angle *k* A D will be found. Thus, to obtain the cutting edges of 70° for a tool whose plan angle is

90°, the tool must be ground at an angle of 61° with the front line A D.

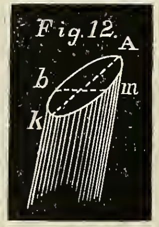
Some very curious results are obtained from this table. Let us suppose that a tool for iron is ground with the plan angle A D 60°. By turning in the column of cutting edges, to the angle 60°, which is the proper cutting edge for iron, we find 0 opposite 60°, showing that the desired form is impossible. It is, therefore, impossible to place the upper plane of the tool at such an angle that will give a cutting edge of 60°. The same plan angle, under a cutting edge of 65°, gives the angle *k* A D equal to 33°, which is too acute for the required strength. A cutting edge of 70° requires the angle *k* A D 47°, which is still weak. Thus no proper edge can be given to an iron-turning tool, whose plan angle is not greater than 60°.

To produce a stronger point, the plan angle of the tool is sometimes ground flat, as at *f m*, Fig. 10, so as to make a short intermediate edge *m n*. The angle of this new cutting edge *m n* is evidently the same as the angle *k* A D in the previous figure, and the table will therefore serve for this new form. It is, therefore, impossible to make the front cutting edge, *m n*, of the same angle as S, for this is more acute, except when the cutting edges are 90°. If it were not for this, this form would give a strong and effective tool, so that it is worth while to examine the objections to it.

Let us suppose the section angle, or the angle at which the two side planes meet, to be 90°; the table shows that, if the lateral cutting edges are 60°, the edge *m n* will be 45°. As this is too acute to be durable, let the front edge be 68°, which will give 70° for the side edges. For iron and steel tools this form is bad, because the difference between the angles of the cutting edges is too great. The best form for these metals appears to be the one in which the plan angle of the point is made as obtuse as possible, and both the cutting edges alike. Thus the plan angle may be made 135°. This corresponds, by the table, to a cutting edge of 60°, and makes the angle *k* A D 57°, producing a very strong tool, similar to the part of Fig. 10 which is included between the planes S and *f*, but having both its cutting edges of the same degree of acuteness.

The same remarks apply, but with less force, to the case of tools for cast iron, whose cutting edge should be about 70°. If to the form Fig. 10 lateral cutting edges *B m*, *C m* of 70° are given, supposing that the side planes are inclined at 90°, the front edge *m n* will be only 61°; if we make this front edge 70°, the lateral edges will be about 76°. The difference is much less than in the former example, but still the form Fig. 9 is preferable. The more obtuse the plan angle is made, the stronger the point of the tool will be. It is better generally to give slide rest tools a large plan angle, as in Fig. 8, where the angle is between 110° and 120°, and make the section angle correspond, in order to get the necessary cutting edges. The plan angle may often be made as large as 150° with advantage. When rectangular pieces are to be cut, the plan angle must be 90°; an angle of 45° then makes the point rather weak, and it will be best to decrease it. It must be understood, however, that unless the plan angle is greater than 60°, it will be impossible to obtain two cutting edges of the necessary acuteness.

Tools are often made with the point rounded off, as in Fig. 11, instead of being terminated by a plane. Such tools are liable to the same objection as Fig. 10, *i. e.*, an impossibility of giving an equal angle to all the cutting edges. This is shown in Fig. 12,



which represents an oblique section of a rounded tool, made at an angle of 45°. The highest part of the edge A, will be exactly at this angle; the lowest, however, will be at an angle of 135°. Between these two points there will be every intermediate gradation. Thus at *l* and *m* it will be 90°, so that between A and *m* there is a variation of 45°. No two adjacent positions, on the same side, will be at the same angle. The highest, A, will be too acute to last, and the lowest, *b m*, will be too blunt to cut. Comparing Figs. 9 and 11, it is clear that the section angle, *k* A D, is the same in both, and that in the round point, Fig. 11, the angle passes through all degrees of acuteness between A and *m*, instead of abruptly changing from one to the other, as at *m*, Fig. 10. Besides this, in a heavy

cut, a shaving which is separated by a rounded tool, and which consequently has a curved section cannot roll itself off the work with the same ease that a ribbon shaving does. It thus opposes greater resistance to the edge of the tool, and dulls it sooner. A forged round nose tool is more difficult to keep in order than one whose edges are planes. This, however, does not apply to cutters held in holders. The round tool should therefore be formed on the same principle as the ordinary double-edged tools, the plan angle being considered only as rounded off in order to avoid having the tool too obtuse or too acute. Care must be taken to place the nose of the tool in the direction of the width of the shaving, for unless the edge is straight, and almost parallel with the face of the work, it will be marked with a series of concave grooves, varying in depth according to the feed given to the tool.

An obtuse-pointed tool seems, then, the best for turning and planing flat surfaces. The edge B D, Fig. 8, should be set nearly or quite parallel to the path of the tool, as from A to B, in turning a cylinder, or planing a flat surface When rectangular faces are to be cut, the plan angle must be 90°, but in general this angle should be larger. For complicated figures, different forms must of course be adopted, but the principle of keeping the plan angle as obtuse as possible may always be used with advantage.

We have supposed, in the table, that the tool rests upon a horizontal plane; the side planes, S, may be considered as vertical, and consequently the line of the section also. It is, however, necessary to incline the planes at about 3° from the vertical. This produces, in A D, an inclination, which varies according to the sine of the plan angle of the tool, but which must be taken into account in the construction of the goniometer. For the angles in the table are the angles k A D, and not the angles which the upper plane makes with the horizontal platform of the slide rest on which the tool is seated The following table shows the angle which A D makes with the vertical line A m, Fig. 9, under different plan angles, always supposing the plane S to make an angle of 3° from the vertical.

Plan angle....	150°.	140°.	130°.	120°.	110°.	100°.	90°.	80°.	70°.	60°.	50°.	40°
Angle of relief..	3°.5′	3°.10′	3°.17	3°.27′	3°.38	3°.53′	4°.12′	4°.44′	5°.11′	6°	7°	8°.39′

The form of the tool having been decided upon, the next most important point is the manner of applying it. Babbage has shown that the principle usually stated, that the point of the tool should be on a level with the axis of the work, or a little below it, is not correct, unless the tool is fixed in such a position as to be perfectly rigid. This rule, when applied to the greatest number of tools and tool holders, which are more or less elastic, is calculated to mislead. Before applying the rule, each tool must be considered, to ascertain what is the position around which the point of the tool will bend when force is applied. This point is called the *centre of flexure.* The correct rule is, that the *centre* of flexure should always *be above* the line, passing through the point of the tool and the centre of the work.

In Fig 4, d C is the line joining the cutting point d, and the centre of the work C. By making the tool weak about Q below this line, that point becomes the centre about which the point of the tool will bend when any unusual force, such as a point of greater density in the metal, is put on the work. In doing so it will describe some part of the arc L d M, from Q as a centre, and *must* dig into the work. If, however, the point P, above the line D C, is the bending point, the point will describe some part of the arc H d G, about P as a centre, and will spring away from the work. The position of the point of rotation can always be commanded, for it is always possible to cut away, so as to make a given spot weak, and produce a centre of flexure at this point. This is a matter of importance, for, knowing beforehand where the rupture will take place, danger to the other parts of the machinery can be avoided, and provision can be made for replacing the broken part.

The forces to be overcome, in removing a shaving from the cylinder, are of two kinds,

which are distinct in the nature of their action, but simultaneous in their application.

1. It is necessary to separate the atoms along the line of action, and tear them apart, thus dividing the material. The force required for this purpose will be dependent upon the metal acted upon, and proportional to the length of the cutting edge of the tool, but will be independent of the thickness of the part removed. It may therefore be said to depend on the nature of the edge, as each metal has its own angle.

2. The shaving cut off by the tool must, in order to be removed, and clear the way for the further action of the edge, be bent, or even curved in a spiral. This force may be said to be dependent on the way in which the tool is applied to the work. When thick cuts are taken, this force is large, and may even be greater than that required to separate the atoms. If the bending were only of small extent, the force to be exerted would vary as the square of the thickness multiplied by some constant, dependent on the nature of the metal operated upon. But the bending is, generally, of such extent that the shaving is broken at very short intervals to such an extent that, though not quite broken through, it is impossible, even after the most careful annealing, to unwind a steel spiral of this sort. This severance of the atoms in the shaving requires the expenditure of considerable force, which may even be greater than that which caused the tool to penetrate. The law by which this force increases with the thickness may be assumed as

$$F = A + B\,t + C\,t^2 + D\,t^3.$$

For the present illustration, it is sufficient to take into consideration only the two forces mentioned above, the constant one and the one varying with the square of the thickness of the shaving. If, therefore, t be this thickness, and A and B two constants, dependent on the nature of the metal, we shall have amongst the forces required for the separation of the shaving

$$A + B\,t^2$$

We can see from this expression, without knowing the values of A and B, that the force required to remove the same thickness of metal may vary considerably, according to the way in which it is effected. If a layer of the thickness $2\,t$ is removed, it may be done in two successive cuts. The force required will then be

$$2\,A + 2\,B\,t^2$$

This might, however, have been done in one cut, when the force expended would have been

$$A + 4\,B\,t^2$$

The force required for making the two cuts will always be less than that required for making one, if t^2 is greater than $\frac{A}{2\,B}$

For let $t^2 = \frac{A}{2\,B} + v$

The force for two cuts will be,

$$2\,A + 2\,B\left(\frac{A}{2\,B} + v\right) = 3\,A + 2\,B\,v.$$

The force of one cut of twice the thickness

$$A + 4\,B\left(\frac{A}{2\,B} + v\right) = 3\,A + 4\,B\,v.$$

So that the force for the two cuts is less by $2\,B\,v$, than the force required for the one.

In the same way it may be proved that if

$$t^2 \text{ is greater than } \frac{A}{m\,B} \text{ or } t^2 = \frac{A}{n\,B} + v$$

it will always require less force to make n separate slices, than to cut one slice n times thick.

The force required for n slices is

$$n\,A + n\,B\left(\frac{A}{n\,B} + v\right) = (n+1)\,A + n\,B\,v.$$

Force required for a slice n times thick

$$A + n^2\,B\left(\frac{A}{n\,B} + v\right) = (n+1)\,A + n^2\,B\,v.$$

The force required for the former is always less than that for the latter, by the quantity $(n^2 - n)\,B\,v$.

The time employed in making a cut is usually the same, whether the shaving is thick or thin, so that the saving in power by taking thin cuts separately would be accomplished at a very great expense of time. This need not be the case, however, if tool holders are employed, so arranged that in the same time several successive cuts can be made. This may be done by having pieces of steel so arranged that one cutter takes the cut after another has finished. By having the cutters so arranged that they can be easily removed, and so that only two faces, at the most, require grinding, the strain on both tool and machine would be less, enabling them to use less power, give better work, and be less easily put out of adjustment.

The principles upon which the cutting edges of tools are formed, having been determined, we find that we can classify all tools as having single or double acting edges, without regard to their real number, according as one or two edges are made to act at one time. The edges of single-edged tools act independently, each

one removing its own shaving, when it is placed in position to do so. Such edges may, therefore, be formed separately. A longitudinal section of a tool, showing the plan angle, will give a true idea of the cutting edges. Double edged tools are so formed that, while both edges act at once, each does its work independently of the other, and both edges have the same degree of acuteness, as has been explained with reference to Fig. 9. The two edges are formed by three planes, an upper surface being common to both side planes, which forms two inclinations with this common plane. One of the edges only, the one below the common plane, forms the angle of relief, so that, as we have seen, the angle at the point has no necessary connection with the cutting edge, and may vary as much as 30° from it, according to circumstances. Thus, as we have seen, the angles of the cutting edges depend on the plan and section angles.

The preservation of the edges after they are formed depends upon the form of the tool, and the position of the cutting edge with regard to the surface of the work. In the case of wood turning, this depends upon the expertness of the workman. In the case of fixed tools it depends on a careful obedience to the principles of the art, since the tool once fixed cannot adapt itself, but must go on as it is guided, until, if it is wrongly placed, either the blunting of the edge or the breaking of the tool in some part requires a new adjustment.

It is well known that different metals and different qualities of the same metal require different angles. The best authorities give :

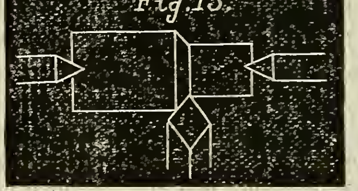
Soft wood	20° to 30°
Ivory and hard woods	40° to 80°
Wrought iron and steel	60°
Cast-iron and steel	70°
Roughing brass	70° to 80°
Finishing "	90°

It will be seen by this table that fibrous materials require tools of much more acute angles than crystalline. While the angles for woods vary between 20 and 80, those for metal vary between 60 and 90.

As heat is always generated to a greater or less extent in turning metals, if the angles were less than 60° the mass of metal would be too small to resist the heat, so that the temper of the tool would be soon lost; or if it was not, the mass would be too weak to resist the strain, and the edge would break or become blunted.

The different tools are formed in different ways, according to the purpose for which they are to be used. In the case of wood the edge works at an oblique tangent, and removes the shaving by passing under its whole width, and we may characterize the action as one of paring. The slide rest tool is at right angles to the axis of the work, and its action is rather that of uncoiling. The width and thickness of the shaving lie in different directions, Fig. 8, The shaving must therefore be cut simultaneously from the face of the work on one side, and from the part being removed on the other; if it is not it will be *torn* from the work, in one of these directions. In what is called roughing,

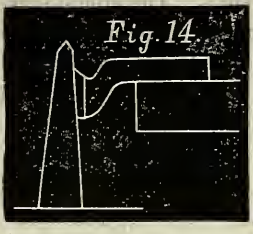
Fig. 13.



it is usual to take the width of the shaving on the superfluous material, as in Fig. 13. The tool thus cuts only on one edge; on the other it will be torn from the work, and the point of the tool will trace a spiral on the face of the work, and the amount of force expended will be a maximum. If the edges, however, are formed so that they can cut, as in Fig. 8, both edges will cut, and the work will have a finished look, and the labor will be reduced to a minimum. The aim, therefore, should be to keep the face of the tool next the work as nearly parallel with it as possible, because it is only that face which leaves any trace of the tool, the action of the other edge being shown only on the shaving.

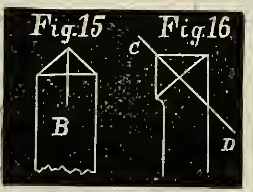
A slide rest tool is in general a double-edged one. It is therefore best to form the sides in such a way that they shall remain invariable, and alter the shape of the tool by grinding its upper face. Naysmith's cone gauge, Fig. 14, allows of a ready means of forming the sides accurately. It is most simply made, of a cone of iron turned to an angle of 3°, and broad enough at its base to stand by itself. Two circles can be traced on it, one showing the height of the centre from the lathe bed, and another showing the height

from the bed or any other part of the slide rest. The tool can in this way be adjusted in the



slide rest, and verified from the lathe bed or the slide rest after it has been fixed in position. The lower faces of each edge are to be applied to the gauge. The front line of the point varies slightly with the variations of the plan angle of the tool, but the section angle is always to be measured from it, whatever its slope may be. This gauge forms a very convenient method of adjustment for inside, and all such tools as are bent from the shank. The principles of the cutting edges remaining fixed, the cone gauge can be applied here as well as in the other cases. It is a very common and a very bad bad plan, when the tool does not exactly suit, to wedge up under one end or the other, thus altering the angle of relief. It is a much better plan to use thin strips of iron or brass of varying thickness, and of about the same length and width as the shank of the tool. The angles are in this way preserved.

In considering the shape of the tool, the first thing to be determined is, whether a single or a double-edged tool is to be used, and the next the construction of the tool, so that it may be applied in the right direction. In double-edged tools the position of the lower faces determines that of the point, which is merely an accident resulting from the meeting of the edges. It must be so ground as to give each edge the same degree of acuteness. Thus



in Fig. 15 the point of the tool is at A and the slope at B; in Fig. 16 the point at C, and the slope is C D.

A large number of tool-holders have at different times been invented, most of them claiming to secure all, or at least some of the theoretical advantages. Holtzapffel has described a number of them; several are in general use, but most of them have too large a surface to be ground, or are defective in their angles.

In the case of hand-turning, which, to a great extent, is a matter of personal dexterity, the correct relation between the edge and the surface may be obtained at will in many different ways, according to convenience or caprice. This is shown in the use of the graver, which is simply a square piece of steel, one of whose ends is ground at will to any required angle, so that by grinding one plane we obtain two acute cutting edges and three heels, from which to use them. The parts principally used are the last parts of the edges towards the point, which are generally strengthened by a minute facette, ground nearly at right angles to them. Generally only one of the edges is used at a time, but it may be used as a double-edged tool.

When it is used for roughing, the point is buried in the work below the centre line, and the lower face cuts the shaving. When it is used for smoothing, the lower face is placed nearly flat against the work. For light finishing cuts the heel may be used, the point being over the top of the work, bringing the cutting edge still further above the centre. There are thus three points to be considered: 1st. The lower face of the edge should occupy the proper position with regard to the surface. 2d. The handle of the tool should be conveniently placed for the operator. 3d. The heel of the tool should be in such a position that it can be firmly held on the rest. The position of the tool should, therefore, be first considered, and the rest then brought up to suit it. The tool once firmly in position, it is to be kept so during the progress of the work; this is a matter of delicacy of touch. When held in a wrong position a strong hand may be able to keep it there; but the edge wears off, the point breaks, and the work is likely not to be true, and is never well finished.

The graver properly belongs to double-edged tools. This will be seen if the point is used. In this case it penetrates the work, and the side edge detaches the shaving, as in Fig 8. The angles of the bar of the graver are 90°. If we wish to make two cutting edges of 60°, we look at 90° under the plan angle in the table, and at 60° under cutting edges, and we find, in the

column of section angles, 45°, as the angle at which the graver should be ground. If it was ground at 61° we should have cutting edges of 70°, and if at 76° cutting edges of 80°. If we increase the plan angle to 140° we should get cutting edges of 60° by grinding at 58°, which shows that the larger the plan angle the larger must also the section angle be in order to get an edge of any degree of acuteness. The greater the plan and section angles, the greater also will be the strength of the point. In ordinary work a tool with a very wide plan angle, ground so as to have cutting edges of 60°, can, if lubricated with water, be made to leave the surface it acts upon polished. It is always wise, in using the graver on gritty substances, such as rough casting, to clean one end with a file, and then to cause the point of the tool to penetrate ; it will thus be buried in the clean metal and preserved. A deep cut may be taken in this way, without danger to the edge. When a very acute point is used for turning small work it must be reinforced with a minute facet; this allows the graver to cut at the point in two directions. We have seen, however, that unless this is done in accordance with the principle of double-edged tools, it is open to great objections.

Tools for brass require cutting edges at angles of 70° to 90°. They are generally very simple, and are round, pointed, and flat right and left tools ; except that they are ground at an angle of 60° to 70° and sharpened at 80° to 90°, they very closely resemble the tools used for hard wood. All roughing work should be done with pointed tools, and no wide surface presented to the work, until the piece has been made true with narrow tools.

For hard wood and ivory the tools require cutting edges at angles of 40° to 80°. The preparatory tool is the gouge, but it is ground less acutely than for soft woods.

The soft wood chisel may be employed on the hardest woods, but this is seldom done, as the tools with single bevels are much more manageable although their edges are nearly twice as thick. The tool is held in the position of a diameter of the circle. The tools are applied on a much greater surface, and the number of different shapes required on this account are very greatly increased. They are placed in short handles, 8 to 10 in.

Tools for soft wood require cutting angles of 20° to 30°. They are mostly chisels and gouges of different sizes. The gouge serves a different purpose from the carpenter's tool, and is really a different one. It is ground obliquely and externally, so that the shape of the edge is elliptical. The bevel lies very nearly in a tangent to the point of contact with the work, the tool resting on its back with the concave side up, or on its side, as different results are to be obtained. The middle edge is the one principally used. The chisel is ground on both sides with a very acute bevel edge, which is oblique to the length of the tool. The angles are 25° to 30° for soft woods, and 40° for hard. The middle and lower parts of the edge are principally used. The tool might be ground square across, but it would then have to be held in a much more oblique position. These tools require long handles, 12 in. to 15 in. In turning tools for soft woods, the elevation of the tool and the angle of its edge are each of them less than in ordinary planes, and in those for hard wood both angles are greater. The hardest woods may be turned with soft wood tools, held as usual; but on the score of economy the angles are increased from 60° to 80°, and the position of the tool changed from nearly a tangent to the direction of a radius, these changes being made with a view of making the tool hold its edge.

The rough exterior faces of all work should be turned with narrow or pointed tools, and only a narrow band at a time, until the faces are true and concentric. To understand the reason for this, we have only to suppose that, while the diameter remains the same, the roughness on the surface of the work were exaggerated four or five times. We should then see that the unevenness consists of inclined planes and detached points, to which, if a wide hand tool is applied, it would be constantly pushed in and out, and up and down ; or, if a fixed tool, it would have an up and down motion entirely incompatible with true work.

After the rough surface has been removed, a tool with a wide edge may be used; or, in the case of the graver, one of its edges may be brought into play. Caution is required, when wide tools are used at right angles to the work, not to apply them to too great a surface at once, as this causes the tool to chatter.

Watch Repairing.—No. 8.

BY JAS. FRICKER, AMERICUS, GA.

We often find one of the pivots of a pinion or staff either broken or badly worn, and instead of putting in a new pinion or staff, we can, by putting in a new pivot, make the old one answer just as well as a new one. The greatest difficulty any one has to contend with in putting in a new pivot is to drill the hole for the pivot; this being accomplished, the rest of the work is comparatively easy.

We will commence with the upper centre pivot, and consider them all, *seriatim*, premising, of course, the watch is one the hands of which are set on the face. Hold the pinion with a pair of tweezers, grasping it by the leaves; then with a blow-pipe, having a small aperture and an alcohol lamp, draw the temper from the extreme end of the pinion, being careful not to heat it so long or hot as to discolor the leaves of the pinion; holding it as directed above materially assists in preventing this.

As the lower portion of the pinion—that part on which the cannon pinion rides—does not often run true with the lower pivot proper, it is best to always true up the pinion in the lathe by the lower pivot, the upper part of the pinion being in the chuck; then make a centre on the projecting end, after which reverse the pinion and true up as before make a small but perfect centre in the end with a sharp-pointed graver, being careful not to leave a little "tit" in the centre, which will now be ready for the drill.

Take a piece of Stubbs wire, small size, or a needle, which is what we usually use; draw the temper then file down to about the size that you intend your pivot to be, filing it nearly straight for at least $\frac{1}{8}$th of an inch from the end, then flatten it on the extreme end with a hammer. Do not flatten it with a *single* blow of the hammer, but strike it lightly, so that you will have to give it several blows; by so doing your drill will not be as liable to crack and crumble when in use. Heat the end red hot, being careful not to burn it, then quickly plunge the end into oil. It is now hard, for say half an inch from the end; make it bright with emery paper, then hold the butt end with a pair of plyers, and the very extreme end of the point in a pair of tweezers, and carefully draw the body of the drill down to a deep blue, and you will have a drill that is very hard on the point, and very tough immediately back of the same. Now lay it on a piece of metal and draw the point down to a very pale straw color. With such a drill you can drill any pinion or staff that has had the temper drawn to a very light blue, or nearly black. Turn the lathe very slowly, using but slight pressure, and plenty of oil, and you will soon have a hole deep enough for your pivot, which should never be less than the length of the pivot, and ought to be twice as deep, unless for very small pivots, when one and a half times as deep will answer. This rule holds good for all except the lower fourth pivot, which, being very long, does not require a hole as deep as it is long. Take a good needle—none but the best quality must ever be used for drills or pivots—and draw the temper to a deep blue, being careful not to pass that point, or it will be too soft. The blue should be of the kind which we always see in tempering polished steel, when it is just passing from a purple to a blue, for very fine work. We always stop at that point just as it is entering the blue. File it to fit the hole, so that it will require some forcing to get it down to the bottom; cut it off before forcing it in sufficiently long to allow for the pivot, and force it in with a few light taps of a hammer; then turn and polish, just the same as if working on a new pinion.

The upper third pivot is put in just as directed for the upper centre. The lower third as well as the lower fourth pivots require more time and care, for we cannot draw the temper in either of these, and our drill will not cut to our satisfaction. After having centred for lower third, make a drill as previously described, omitting the "drawing of the point to a light straw," as in this case we must have a very hard drill. We omitted to mention, in directions for making a drill, to state that after it was tempered properly, it should be held in a pin vice, and, with one flat side resting on a piece of Arkansas stone, take another piece of Arkansas stone and grind it down flat, then sharpen it, when it will be ready for use. With such a drill, plenty of oil, and turning

the lathe *very slow*, not over one or two revolutions in a second, and using considerable force on the drill, a hole can be made deep enough in much less time than one could think, for the great trouble is, we get in too much of a hurry, and either *force* the drill too much, or bend it to one side; consequently, in either case, have a broken drill; and in some instances it takes some considerable time to remove the piece of drill left in the hole, besides having a new drill to make. If you break a drill, don't be so foolish as to get mad, but quietly file up a piece of tempered steel and "pick" at it until you get it out. Same directions apply for putting in the pivot as for the centre. The upper and lower fourth same as upper and lower third. The scape pivots are usually put in same as lower third; sometimes we remove the scape wheel, and draw the temper for the upper pivot. The pallet staff pivots can be easily put in, as either end can be "drawn," always polishing up that part that was discolored by the heat, of course.

In putting in a new pivot in the balance staff, *always* remove the balance, if an upper pivot is needed, and *generally* so, if a lower one is to be put in; then draw the temper, holding the opposite end in a pair of plyers, first wetting the jaws of the plyers to insure perfect protection to the opposite or good pivot. After having finished the pivot, if an upper one, or, if the lower, the staff must be reversed and trued up, fit on the balance, and rub it on tight with a burnisher. If the balance is an "adjusted chronometer balance," great care must be exercised and not overheat it, as its adjustment would be materially affected.

Although we gave directions for putting in a new upper centre pivot in the December No., we thought it best to go more into the details this time, and include the other pivots, so as to have the whole subject of putting in a new pivot complete in one article. We hardly deem it necessary to give detailed directions for putting in a new third or fourth wheel; suffice it to say, before riveting them on, they must be trued up by the periphery, and the hole in the centre made concentric with the outside or extremity of the teeth.

It frequently happens, in the more ordinary grades of English levers, that either the third or fourth wheels are rather large or small, or that the teeth are of a bad shape. In either case a new wheel must be substituted for the defective one. Whenever any doubt exists as to the depth being correct, set your depthing tool accurately by the holes in the plates, and then try in the doubtful pinion and wheel. If the depthing is correct, and the teeth the proper shape, the *entering* tooth will not come into action until it is near the line of centres, and produces a rolling action, not a *sliding* one. Try them carefully, both with a shallow and a deep depth, and carefully notice how they act in different positions; for, to determine whether the depth is correct or not requires some good common sense and experience. No one can learn how to do good work by books alone; it requires *experience* and *thought*; it takes time and patience to become *au fait* in horological as well as other matters. A watch will sometimes run and keep very good time when the third wheel is somewhat too large or too small, but the same error in the fourth wheel will cause the watch to stop occasionally; being so much farther from the motive power is the cause of this. In a case of this kind the "botch" will put in a stronger mainspring instead of correcting the error. If new beginners, and, in fact, all those who have never had the benefit of proper instruction, would use the depthing tool more frequently, they would have better success. Some watch breakers we wot of do not seem to care to have their bench cumbered with a depthing tool.

In our next we will take up the escapement. It is not our intention to go into a learned and scientific dissertation upon this subject, *a la* Grossmann, but simply to give some practical information as to the proper plan to pursue in repairing the defective, broken, or worn parts of an already existing escapement. We wish to make these articles so plain and practical that the apprentice can easily understand and utilize them, which will stimulate him to study such scientific works on horological and kindred subjects as are now published, and tend generally to make him a good workman, if not a scientific horologist. It has been suggested, that when these articles are brought to a close, that we write a series of articles on the lathe. We don't *promise* anything of this kind, but *may* do so.

Refining Old Gold.

The first step in this process is to sort out all the base metal to which no gold or silver is attached, and being particularly careful to break off the iridium from the gold pens, as it is so refractory that it will not melt, and so insoluble that it cannot be eliminated by acids, and when embedded in the gold will always give trouble in filing and polishing. Whenever it does come to the surface in polishing up a piece of gold work, the easiest way to get rid of it is to dig it out with the graver and fill up the cavity with gold solder and refinish the spot.

If there are hollow pieces among the old gold, flatten them together so as to reduce them to as little bulk as possible, pack the whole closely into a suitable sized crucible, filling the interstices with saltpetre, and submitting it to the highest heat of the forge. It is sometimes well to invert and lute into it a crucible, through the bottom of which a hole has been punched, which will prevent the too rapid volatilization of the nitre.

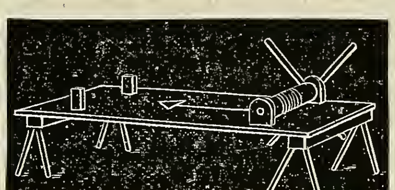
It will be necessary to continue the heat an hour or more, in the meantime adding more nitre, some adding also a small quantity of salt. The object of this long-continued fusion is to burn out, oxidize, and volatilize, all the base metal, such as tin, lead, zinc, etc., and even the copper can be partially burned out by this process. When it is supposed to have become purified, it may be poured out into cold water, which granulates it, breaks it up into small grains, which must then be collected, put into a clean crucible, more nitre added, and the whole again melted and poured into an ingot. Its quality and malleability can then be examined, the former by the test needles, as described on page 251, Vol. II., of the Journal, and the latter by hammering and rolling.

It will sometimes occur—in fact not unfrequently—that the mass obstinately refuses to become ductile, and another ordeal of fusion must be gone through with. Should this fail to produce a workable bar, the shortest way will then be to "part" it—that is separate the gold and silver. This is done by adding to the mass of melted metal sufficient silver to reduce the whole to about 6 carats ($\frac{250}{1000}$) fine. This will rarely fail to be malleable, and must then be rolled out into a thin ribbon, coiled up loosely, or cut into small bits, and dissolved by nitric acid. This is best done by setting the vessel containing it into warm sand or ashes, where the fumes that arise will be drawn up the chimney. The silver will be taken up by the acid and remain in solution as a nitrate, while the gold will fall to the bottom of the vessel, in a powder. The liquid must be carefully poured off, the gold powder washed with fresh water, collected, dried, put into a clean crucible with borax, melted and cast into an ingot, if of considerable quantity, otherwise left to cool, as a button of fine gold in the bottom of the crucible. The silver can be precipitated from its solution, and recovered in the metallic form by immersing in it a plate of copper, thus transforming the silver solution into nitrate of copper, and precipitating the silver in the form of gray powder, which can be melted into a bar or button, as was the gold. By this process *pure* gold and silver are obtained, from which can be compounded such alloys as may be desired, by the formulas shown in the article on alloys previously referred to. The nitrate of copper can be recovered in crystals by evaporating the solution to dryness.

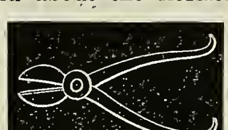
In working the gold into plates or wire, frequent annealings are necessary, because it rapidly hardens, and becomes difficult to farther flatten or draw, and also because of the tendency to crack. Frequently in working out plates the edges will commence to crack, and if the rolling was continued the cracks would so run into the plate as to spoil it. This can sometimes be remedied by trimming off the edge with a shears, cutting the crack quite off, or, if only one or two cracks occur, they can often be prevented from extending farther by filing them out. Hollow wire of various sizes is an article of great convenience, if not of absolute necessity, to the jobber, and is easily made from plate. Roll out the gold to the requisite thickness, cut from this a strip in width a trifle more than three times the diameter of the intended wire, form one end of this strip into a taper before bending up the whole strip into a rude tube, insert the taper end into the proper sized hole of the wire plate and draw it through; this will nicely round up the hollow wire, which can be further reduced in size if desired, the same as for solid wire. By drawing the joining or crack along, the whole length

becomes so close that it is not easily seen ; some workmen notch the wire slightly all along this side after it is drawn so as to readily distinguish upon which side the opening is ; for when using hollow wire for joints, the opening in it is placed downward so that the solder flows into it, thus making it as firm as it would be were the seam soldered before it was drawn.

Solid wire, in such small quantities as is required in a repair shop, is easiest made from plate of a thickness considerably greater than the intended diameter of the wire to be used. From such plate strips can be cut off in width equalling the thickness which forms square wire. This must have the corners rounded somewhat by the hammer and file, which will give a rough round wire, one end of which must be filed to a taper that will permit it to pass far enough through the first hole of the draw plate to be seized by the draw tongs, or if small wire, by hand-plyers. This filing down the corners is necessary, because, if they were drawn down by the plate itself, they would be more or less crushed over upon the flat edges, making an imperfect surface—not compact and solid which, in the many subsequent uses, would rough and splinter up in a very objectionable manner. All wire smaller than heavy pendant bows can be drawn by hand, if the wire plate is immovably fixed, but for larger wire a draw bench will be required. The simplest form, and one that any one can improvise, is made as shown in the cut.



A piece of plank upon legs, with a wooden roller across one end, to be revolved by the cross arms, and at the other, two strong pins, against which the draw plate rests, either strap or cord wound about the horizontal windlass,



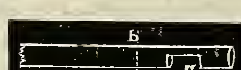
the free end secured to a three cornered ring, which hooks on to the draw tongs, which are so constructed that the harder the draw, the tighter they hold on.

Frequent annealing will be found necessary in wire drawing, and the wire must be lubricated as it passes through the plate; beeswax is most commonly used for this purpose, although soap, tallow, or almost any tough unguent will answer; *fluid* lubricants are not so good, because the great pressure squeezes it entirely out from between the hole and the wire. Beeswax seems to answer best, from the fact that it is so tenacious that a thin film adheres to the wire in spite of the pressure upon t.

When hollow wire of considerable size is required, such as for chain mountings, pencil barrels, snaps, and tips, an inside "form" of steel must be used, which will preserve the interior size constant, but allows the thickness of the tube to be reduced. In this way tubing of various shapes is produced, as was shown in the article in the JOURNAL descriptive of pen making.

In using hollow wire for joints, etc., in jobbing, the novice is often sorely bothered by the solder flowing in and filling up the hollows, resulting in having a solid joint instead of a hollow one. This is easily prevented by filling the hole with a little bit of wood previous to soldering. The wood, of course, burns out, but the cinder and ash left prevents the flow of solder into the hole. Another thing that often plagues the amateur jeweller is putting joints upon spectacles, as shown in the figure. The

difficulty is in keeping the joint in place while soldering. Usually only one side is broken off, but it is easier to put on two than one. Break off the other, and make a clean concave with a round file for the new joints; take the hollow wire and file into it a notch upon the side where the seam is in the wire, as in the figure ;



let the notch *a* fit the small part on the temple ; cut it off at *b*, and lay it in the prepared concave ; pin it down and solder. By filing

through into the notch a good square joint is formed with little trouble. Joints for brooches, pins, etc., are put on in the same way.

———o———

Brains vs. Whiskers.

There is very much talk by a certain class of moralists about the signs of the times, but what inference are we to draw from the following, which appeared under the heading of Trades Advertisements in a recent issue of a New York morning newspaper:

WANTED—A Clock Repairer, with some brains and no whiskers. Address PINION, giving reference.

We have always had an idea that most men possessed of brains had either whiskers or desired to have them, but now it would appear that whiskers and brains do not always go together, or at least some people desire that nature should not distribute both of these bounties to one person. We feel curious to learn if Mr. Pinion is positively against the general wearing of whiskers, or is it a preponderance of that manly appendage that he dislikes so much in his workmen? Has any of his former employees neglected his business interests while attending to their whiskers, or have the successful efforts of some aspiring young man in his employment to raise a beautiful crop rendered him obnoxious to his employer? Do the visits of the clock repairer to the dwellings of his employer's customers while in the pursuit of his calling create too great a sensation among the maid servants of the establishment if he happens to be possessed of a killing pair of whiskers, or has the advertiser been reading Æsop's fable of the wolf and the goat? Whatever be the reason, it is evident that a man who has whiskers will not suit Mr. Pinion's purpose, because he states distinctly that applicants are to send references that they have some brains and no whiskers.

If we are to take this advertisement as an evidence of a more abundant distribution of whiskers than brains among the clockmakers of New York, without saying anything in disparagement of whiskers, we would advise our friends who are employed in this branch of our profession to be very careful not to cultivate their whiskers at the expense of their intellect, else others, as well as Mr. Pinion, may be liable to judge the size and quality of their brains in the inverse ratio to the size of their whiskers, and these remarks may also apply to other clockmakers or repairers as well as those of New York.

———o———

Remarks on Clyde's "Additional Remarks."

Ed. Horological Journal:

I find it is required on my part to define the position which I have taken in regard to a "*certain law in friction*," because your correspondent, "Clyde," in his "Additional Remarks," in the January number of the Journal, exposes a disposition to ridicule what he does not appear to understand, in the way he refers to my contrivances for the purposes of finding out what effect external motion has on the pocket chronometer. He first wonders whether I mean what I write, when I say "the laws of nature cannot always be followed with advantage," and then "inclines to think that I must mean it" when he considers a certain *other* position which I have assumed in a later article. It is ingenious, but I do not like the spirit that puts it in force.

I said that nature cannot make the "simple shakes" which the machine pocket makes; that is, motion which is *perfectly exempt from circular influence*, and such as is *all* circular. Nature mixes all up into a compound. That "Clyde" does not comprehend the situation is no fault of mine, because I tried my best to make the article referred to so plain that all watchmakers can understand it in that part where I said that art goes ahead of nature. This "Clyde" does not realize.

My position on the friction question refers to one of the *many* laws in friction, and may be put thus: "*A certain law in friction cannot be followed with advantage under the imperative necessity of lubrication, as regards watch escapements and balance pivots.*" Any one who reads my article "Friction in Difficulty," will see the same, but not in a single sentence. "Clyde" suggests that B. F. H., and Mr. Hagey come over to his side. This is not "*inclining*" the human mind, it is an endeavor to *propel* it. I need not tell B. F. H. that the eight column article goes over old ground.

Nobody wants this established law "proved," which is of so great advantage for the purpose of reducing pressures known as "pressure per square inch." The end of a balance pivot, for instance, requires all the metal that it has in order to keep down the pressure per square inch. "Hollow out the ends of the pivots" is a very bad thing, because the pivot end has no metal; yet this is "Clyde's" best plan (p. 161), showing that he thinks of one thing and not of another. "From nature, too, I take my rule." J. MUMA.

Hanover, Pa.

———o———

Answers to Correspondents.

R. P., *Bridgeport, Conn.*—The usual bronze powders are really metallic. The metals employed are for the most part copper and zinc, which are made into an alloy and then reduced into an impalpable powder. The first and most common method of obtaining the powder, is to beat the alloy into thin leaves, which are rubbed with a scratch brush through an iron sieve. After being ground with oil the powder is heated until the desired tint is produced. The alloy may be reduced by filing, and the sharp angular particles thus formed are flattened by rollers. A good bronze is also made by passing over highly heated oxide of copper the vapor of the petroleum product known as Rhigolene, sixteen pounds of which will reduce two hundred pounds of copper. After being allowed to cool in the same vapor it is lamellated in a mortar. Various shades may be given to this powder by means of the vapor of zinc or cadmium. If the oil used in reducing the oxide contains a little sulphur, beautiful variegated colors will be produced. The proportions of the metals ordinarily used are, for a bright yellow, eighty-three parts of copper and seventeen of zinc; for an orange, from ninety to ninety-four of copper, and from six to ten of zinc. A red bronze is composed entirely of copper.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For May, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be subtracted from Apparent Time.	Diff. for One Hour.
		s.	M. S.	s.
Thursday	1	66.08	3 3 99	0.307
Friday	2	66.16	3 11.10	0.285
Saturday	3	66 24	3 17.67	0.263
Sunday	4	66.32	3 23.71	0 240
Monday	5	66.40	3 29 20	0 217
Tuesday	6	66.48	3 34.16	0 194
Wednesday	7	66.56	3 38.57	0 171
Thursday	8	66.65	3 42.41	0 148
Friday	9	66.73	3 45.70	0.125
Saturday	10	66.81	3 48.44	0.101
Sunday	11	66.89	3 50.55	0.077
Monday	12	66 98	3 52 13	0.053
Tuesday	13	67.06	3 53.16	0.029
Wednesday	14	67.14	3 53.56	0.005
Thursday	15	67 22	3 53.40	0.019
Friday	16	67.31	3 52.66	0.044
Saturday	17	67.39	3 51.36	0.068
Sunday	18	67.47	3 49.48	0.092
Monday	19	67.55	3 47.01	0.116
Tuesday	20	67 62	3 43.96	0.139
Wednesday	21	67.70	3 40.36	0.162
Thursday	22	67.77	3 36.20	0.185
Friday	23	67.84	3 31.51	0 207
Saturday	24	67.91	3 26 29	0.228
Sunday	25	67.98	3 20.55	0.249
Monday	26	68 05	3 14.31	0.270
Tuesday	27	68.12	3 7.60	0.290
Wednesday	28	68.19	3 0.41	0.309
Thursday	29	68.25	2 52.77	0.327
Friday	30	68 31	2 44.68	0.345
Saturday	31	68.37	2 36.16	0 363

Mean time of the Semidiameter passing may be found by subtracting 0s.18 from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	4 0 32.2
☉	Full Moon	11 23 17.8
☾	Last Quarter	18 23 0.4
●	New Moon	25 21 20.5

		D. H.
☾	Apogee	5 5.5
☾	Perigee	19 12.2

Latitude of Harvard Observatory .... 42° 22 48.1

	H. M. S
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1·42.64

	APPARENT R. ASCENSION. D. H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE H. M.
Venus	1 2 55 31.24	+22 5 9.2	0 17.5
Jupiter	1 9 38 2.94	+15 18 36.5	6 59 0
Saturn	1 20 19 51.80	−19 46 21.4	17 39.1

AMERICAN

Horological Journal.

Vol. IV. NEW YORK, MAY, 1873. No. 11.

CONTENTS.

ESSAY

ON

WATCHMAKERS' REGULATORS, WITH PRACTICAL DETAILS FOR THEIR CONSTRUCTION.

BY HENRY J. N. SMITH.

CHAPTER IV.

DIRECTIONS FOR MAKING THE FRAMES, ETC.

The frames of many regulators are, I think, made too large and heavy. In some cases there may be good reasons for making them large and heavy, but in most instances, and especially when the pendulum is not suspended from the movement, it would be much better to make the frames lighter than we frequently find them. Very large frames present a massive appearance, and convey an idea of strength altogether out of proportion to the work a regulator is required to perform. They are more difficult and more expensive to make than lighter ones, and after they are made they are more troublesome to handle, and the pivots of the pinions are in greater danger of being broken when the clock is being put together than when they are moderately light.

In a clock such as we have under consideration, where the frame is not to be used as a support for the pendulum, but simply to contain the various parts which constitute the movement, the thickness of the frames may with propriety be determined on the basis of the diameter of the majority of the pivots which work into the holes of the frames. The length of the bearing surface of a pivot will, according to circumstances, vary from one to one and a half times the diameter of the pivot. The majority of the pivots of our regulator will not be more than 00.5 or 00.6 of an inch in diameter; consequently a frame 00.15 of an inch will allow a sufficient length of bearing for the greater portion of the pivots, and will also allow for countersinks to be made for the purpose of holding the oil. One or two of the larger pivots will be run in bushes placed in the frame, as will be described in a future chapter.

The length and breadth of the frame, and also its shape, should be determined solely on the basis of utility. There can be no better shape for the purpose of a regulator than a plain oblong, without any attempt whatever at ornament. For our regulator a frame nine inches long and seven inches broad will allow ample accomodation for everything, as may be seen on referring back to Figure 11, which is engraved on a scale approximately one-half the full size.

At the present day frames are mostly made from sheet brass, which is a great convenience over cast brass, providing it can be obtained of a quality suitable for the purpose. A large portion of the stock of sheet brass kept by hardware dealers is too soft for the purpose, and, on account of the ingredients it is composed of, no amount of hammering will make it hard. One may just as well try and make a piece of lead hard with the hammer. The sheet brass best adapted for the clockmakers' purpose is the same kind that engravers prefer for their work. It is hard, and at the same time cuts free, and if a piece of it is nicked round with a file it can be broken off like steel. When on a visit to the Scoville Manufacturing Company's works, at Waterbury, Conn., I saw

sheet brass in the course of manufacture which is very well adapted for making frames, dials, wheels, etc. Small quantities of this brass may be had through Messrs. Frasse & Co., 62 Chatham street, N. Y., or from other dealers in light machinists' tools and materials; and if special instructions be given, the brass will be cut to any desired size or shape, and made flat, which, to those making but few clocks, is a great convenience, because flattening large pieces of thin metal is an art which can only be acquired by extensive practice. Should the brass not be as flat as is desired, saw-makers are very well qualified to flatten it perfectly. A person accustomed to flatten saws will flatten a clock frame or a dial very nicely, and will make no deeper hammer marks on the surface than can be ground out with pumice-stone and water.

If any reader should be so situated that he cannot obtain sheet brass of a suitable quality, or if he is engaged in making a regulator as a recreation in his hours of leisure, and desires to make the frames himself, he may either get the brass cast into the desired shape at some brass foundry, or he may cast it himself if his taste inclines in that direction. A mixture of about 4½ lbs. of copper to 1½ lbs. of zinc will be found to be suitable for the purpose. Ample directions for casting brass have already been given by Mr. B. F. Hope, of Sag Harbor, in the third volume of the JOURNAL.

After the brass has been cast, it is necessary that it should be hardened or tempered with the hammer. This is an important operation, and requires a considerable amount of care to do it as it ought to be done. In hammering a frame begin at the edge and apply the blows of the hammer in regular rows from one end of the frame to the other till the whole frame has been hammered. Then turn the frame over and apply the blows on the other side, and in rows *across* the frame, or at right angles with the rows of hammer marks on the other side. After the frames have been hammered in the above manner they are to be flattened, and as the process of flattening goes on, it will be noticed that the frame can only be made flat by stretching certain portions of it which may not have received so much hammering as the others. Stretching these parts of the frame a little is the only way by which it can be made flat.

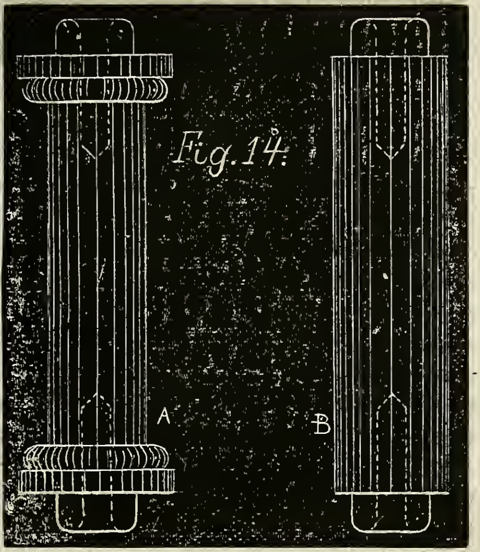
When frames made from cast brass have been made flat with the hammer, the best way to smooth them and bring them to an equal thicknes is to turn them in a lathe that has a slide rest. The frame should be pinned or screwed on to the face of a perfectly flat hard wood chuck, and small cuts taken off with a diamond-pointed tool fastened in the slide rest. I call attention to the necessity of taking only small chips off at a time, because, when large chips are taken off, one side of the frame is liable to become heated before the other, and from that cause the frame is liable to get out of flat. The safest way is to take a small chip off from one side and then turn the frame the other side up and take a little off that side, and so on till the brown marks have all been removed from both sides, and the frame brought to an equal degree of thickness. The last cut should be made with a round pointed tool which has been very carefully ground on an oil-stone. In work of this kind a round pointed tool cuts smoother than a tool of any other shape. I do not pretend to give any reason for this, but simply mention the fact. The marks left by a tool of this description, when used in a good lathe, will be easily polished out with blue stone and water.

After the frames have been turned and brought to an equal thickness in the manner described, they are stoned lengthwise, across, and in every other direction, till all the turning tool marks disappear, when the two frames are cleaned and placed together with their edges as even with each other as possible, and two holes, about one-tenth of an inch in diameter, bored through them both, one at each end of the frame and near to the edge. The use of these holes is to put pins through to hold the frames evenly together while the edges are being filed square, and when the holes for the pillars and the pivots are being bored; consequently too great care cannot be exercised in order to bore these holes straight and the pins fitted accurately to them. After the edges have been filed square the frames are ready to receive the pillars.

PILLARS.

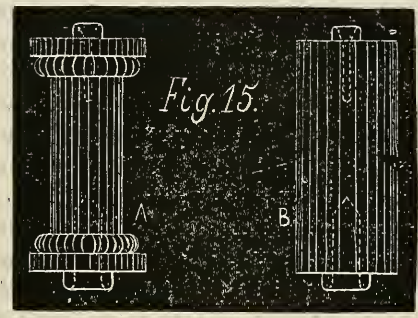
Figure 14 represents the exact size of two pillars, any of which will be suitable for our regulator. Probably the pillar marked A will be the most desirable, because the shoulders

which the frames rest against are the broadest, and on that account the pillars will be likely to stand straighter in the frame. If we make a plain pillar with the shoulders as broad as they are in A, it makes the pillar too heavy; hence the desirability of using a pattern something like A. Pillars are usually made of cast brass. A pattern is turned from wood, and a little larger in every respect than the pillar is desired to be. If there is to be any ornament put on the pillar, it is never made on the pattern, because it makes it more difficult to cast, and besides, the ornamentation would all be spoiled in the hammering. The pattern must be turned smooth, and the finer it is the better will be the

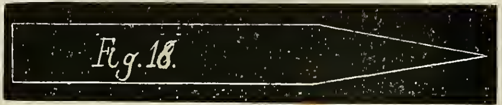


casting. After the casting is received the first thing to be done is to hammer the brass, and then centre the holes, because it will be seen from the diagram that there are holes for screws at each end of the pillar. Holes of about 00.20 of an inch are then bored in the ends of the pillars, and should be deep, because deep holes do no harm and greatly facilitate the taping for the screws. After the holes are taped, countersink them a little, to prevent the pillar from going out of truth in the turning. It will depend a great deal on the conveniences which belong to the lathe the pillars are turned in as to how they will be held in the lathe and turned. If the holes in the end of the pillars have been bored and taped true, and if the lathe has any kind of a chuck suitable for holding stout wire, the best way is to catch a piece of stout steel wire in the chuck and turn it true, cut a true screw on it, and on this screw one end of the pillar, and run the other end in a male centre. However, if the screws are not all perfectly true, and the centres of the lathe not perfectly in line, this plan will not work well, and it will be necessary to catch a carrier on to the pillar and turn it between two male centres.

Figure 15 is a full-sized representation of two patterns of dial feet which are precisely the same as the pillars, only smaller. These



dial feet are intended to be fastened in the frame by a screw, the same as the pillars; but it will be observed that the screw which is intended to hold the dial on the pillar is smaller. The dial feet will be turned in precisely the same manner as the pillars. Figure 16 is a



small sized representation of a tool for finishing the plain surfaces of the pillars and dial feet. An old 6 or 7 inch smooth file makes a good tool of this kind. A piece is broken off the end of it, and the end is ground flat, square, or slightly rounded, and perfectly smooth. The smoother the cutting surface the smoother the work done by it will be. It is difficult to convey the idea to the inexperienced how to use this tool successfully. In the first place, a good lathe is necessary, or at least one that allows the work to run free without any shake. In the second place, the tool must be ground perfectly square, that is, it is not to be ground at an angle like an ordinary cutting tool. Then the rest of the lathe must be smooth on the top, and the operator must have confidence in himself, because if he thinks that he cannot turn

perfectly smooth it will be a long time before he is able to do it. Figure 17 is a representa-

tion of a tool for turning the rounded part of the pillar, if a pattern of this style is decided on. It is made by boring a hole, the size of the desired curve, in an old file, or in a piece of flat steel, and smoothing the hole with a broach and then filing away the steel, as is represented in the diagram. This question of ornament is, however, all a matter of taste. Personally I do not care for ornament of this kind, but a little of it is harmless on the pillars or dial feet. The parts which I wish to direct the greatest amount of attention to are the formation of the shoulders and the points which go into the frames. These shoulders should be smooth and flat, or a very little undercut, and the points should be rounded as is shown in the diagram, because rounded points assist greatly in making the frames go on to the pillars sure and easy, and greatly lessen the danger of breaking a pivot when the clock is being put together.

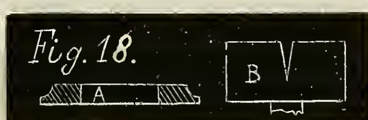
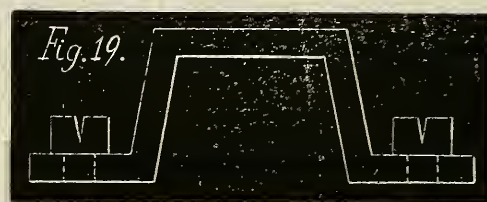


Figure 18 is a full-sized representation of the head of a screw, and the size and shape of a washer that will be suitable for fastening the pillars in the frames. When a washer is used the points of the pillars project half the thickness of the washer through the frames, the hole being large enough to go on to the points of the pillars. Perhaps it would be well to mention here that an ordinary shaped drill is not the one best adapted for boring a hole in the frame so large as is required for the pillars. A drill shaped and made like a tool for making a flat countersink suits this purpose best. It does not chatter, and bores a smoother hole. A small hole should be bored first with a common drill, exactly the size of the tip on the point of the large drill, which is shaped like a flat countersink. Should the large drill chance to be a little too small, and the hole require a little broaching, a very good broach is easily made by turning a piece of wood to the desired size and fastening a piece of thin steel or a piece of a broken mainspring to it. The best way to fasten the steel to the wood is to cut the wood up in the centre with a saw and insert the steel in the cut. A large broach made in this way will cut a smooth hole, and when used on brass it will last a long time, although the steel used be soft.



COCKS.

Figure 19 is a full sized outline of the cock required for the pallet arbor, and the only cock that will be required for the regulator. It is customary, in some instances, to use a cock for the scape-wheel and also for the hour-wheel arbors, but particularly for the scape-wheel arbor I consider that a cock should never be used when it can be avoided. The idea of using a cock for the scape-wheel arbor is to bring the shoulder of the pivot near to the dial and thereby make the small pivot that carries the seconds hand so much shorter; and so far this is good, but then the distance between the shoulders of the arbor being greater, when a cock is used the arbor is more liable to spring and cause the scape-wheel to impart an irregular force to the pendulum through the pallets. This is the reason why I prefer not to use a cock except when the design of the case is such that long dial feet are necessary, and renders the use of a cock indispensable. In the present instance, however, the dial feet are no longer than is just necessary to allow for a winding square on the barrel arbor, and therefore a cock for the scape wheel is superfluous. Better to use a long light socket for the seconds hand than put a cock on the scape-wheel arbor in ordinary cases. Except for the purpose of uniformity a cock on the hour wheel is always superfluous, although its presence is comparatively harmless. The front pivot of the hour-wheel axis can always be left thick and strong

enough should the design of the case require the dial feet to be extra long.

For the pallet arbor, however, a cock is always necessary, and it should always be made high enough to allow the back fork to be brought as near to the pendulum as possible, so as to prevent any possibility of its twisting when the power is being communicated from the pallets to the pendulum. This cock should be made about the same thickness as the frames, and about half an inch broad. Make the pattern out of a piece of hard wood, either in one solid piece or by fastening a number of pieces together. The pattern should be made a little heavier than the cock is required to be when finished, and it should also be made slightly bevelled to allow it to be easily drawn from the sand when preparing the mould for casting. After it is cast the brass should be hammered carefully, and then filed square, flat, and smooth.

FORMING THE WHEELS.

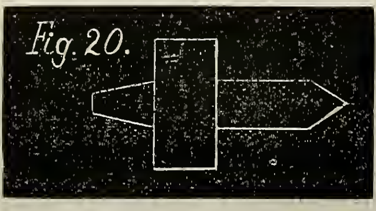
The brass from which the wheels are made ought to be of the very finest quality that can be obtained. Bad brass spoils the cutters for cutting the teeth, and no amount of care can produce a good smooth tooth if the brass, which the wheel is made from, is not good. The best brass for this purpose which I know of that can be obtained in the United States is the "Lancashire" brass made by the Scoville Manufacturing Company. It is hard, and cuts free and smooth, and the cutters used in it will last a long time. If this quality of brass cannot be obtained thick enough for the great wheel, a piece of the same brass the frame is made from makes a good substitute. For the purpose of a regulator it is always best to use sheet brass for the wheels, and cut them out of the solid to the desired shape and size. If good sheet brass cannot be obtained, then the next best resource is cast brass, and this should be made from the very best ingredients that can be procured. The brass for wheels should not be hammered in the same way as for frames. Instead of the blows being applied in lines across the metal, they should be applied in circles, beginning in the centre of the wheel and gradually approaching the edge. The blows should not be heavy, and the thinner the metal the lighter the blows should be, continuing the hammering till the hammer will not make an impression on the brass.

After the brass has been hammered, the best way to make it smooth and of an even thickness is to turn it the same as the frames have been done, but a different kind of a chuck will be required. The chuck must be made from metal and turned perfectly true and flat. In the centre of the face of the chuck a hole must be bored a little smaller than the hole that has to be in the centre of the wheel. This hole is taped, and a piece of taped wire is screwed into it as tight as possible. The hole in the centre of the wheel is also taped, and this screw holds the wheel on the chuck while it is being turned. The screw on the hole in the centre of the wheel is broached out after the sides of the wheel have been turned. The same precaution to prevent the wheel from twisting by heat is required to be practised as was done when turning the frames.

The number of arms or crosses to be put in a wheel is usually decided by the taste of the person making the clock. There is, however, another view of the subject, which I would like to mention. With the same weight of metal a wheel will be stronger with six arms than with four or five, and as lightness, combined with strength, should be the object aimed at in making wheels, I would prefer six arms to four or five for the wheels of a regulator. In cutting out the arms, instead of boring a number of small holes it will be found to be easier to bore one or two large holes for each arm, and file them with a large round file till there is room enough obtained to use other files.

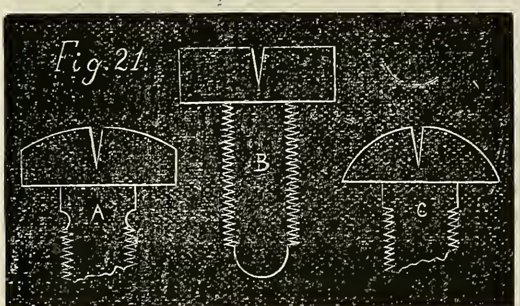
SCREWS.

Perhaps it will not be out of place here to make a few remarks on the subject of screws. Hard brass or gun metal screws are well adapted for all the purposes of large screws in



a regulator. Figure 20 is the shape of a casting required for making screws. After the screw has been turned, and the thread cut, and

the head formed, the superfluous piece in the casting is then sawed off. The threads of screws vary in proportion to the size of the screw and the material from which it is made. A screw with from 32 to 40 turns to the inch, and a thread of the same shape as the fine dies for sale in the tool shops make, is well adapted for the large screws in a regulator. However, it is not the threads of the screws I desire to call attention to so much, although it must be admitted that the threads are of primary importance. It is the shape of the heads and the points which is too often neglected. Figure 21



presents a view of three screws. The point of the screw marked B is the best kind of point for a screw to enter into its hole without difficulty. A thread, or a thread and a half, cut down on the point of a screw, as is shown at B, will always cause a screw to enter easier than when the point is flat, round, or shaped like a centre. This is not a new idea for making the points of screws, but the plan is either not known to many, or it is not practised to the extent it ought to be.

The shape of the head of a screw should also always be based on utility, and the shape that will admit of a slit cut into it that will wear well should be selected. A round head like C, Fig. 21, ought never to be used, because a head of this shape does not present the same amount of surface to the screw-driver that a square head does. It is the extreme end of the slit that is most effective, and in round-headed screws this part is cut away and the value of the head for wearing by the use of the screw-driver is the same as if the head of the screw was so much smaller. A head shaped like A may suit the tastes of some people better than a perfectly flat head like B, but in a head of this shape the slit must be cut deeper than in a square head, because the rounded part of the head is for little or no use for the screw-driver to act against. The slits should always be cut carefully in the centre of the head and the sides of the slit filed perfectly flat with a thin file and slight burr filed off the edge to prevent the top of the head getting bruised by the action of the screw-driver. The shape of the slit, which is best adapted for wearing, is one slightly taped with a round bottom. The round bottom gives greater strength to the head, and prevents the heads of small screws from splitting.

I have dwelt at some length on these little details because a proper attention to them goes a long way in the making of a clock in a workmanlike manner, and it is desirable that the practical details should be as minute as possible.

[TO BE CONTINUED.]

Principles and Laws of the Isochronism of the Vibrations of the Balance by the Hairspring.

Translated from the works of FERDINAND BERTHOUD.

BY THEO. GRIBI, WILMINGTON, DEL.

FIRST PROPOSITION.

150. The inflexions* of two springs of equal length but of uneqal strength are in an inverse ratio to their forces. If, then, we have a spring which has twice the force of another, and both be of the same length, the weaker one will be capable of double the amount of inflexion of the stronger, and both will be subject to the same amount of tension at the limit of their inflexion.

151. From this it follows that, having a given balance, to which a hair-spring of a given length has been applied, if the large vibrations of this balance are performed in less time than the small ones, we shall be able to render them isochronal by employing a weaker spring, its length remaining the same; for, the extent to which the spring is capable of inflexion being thus increased, the ascending progression of its force will diminish in proportion, but the balance will, in this case, make a less number of vibrations in a given time. We are thus en-

* By inflexion is meant the space which a spring may be moved over without straining it.

abled to arrive at isochronism without changing the length of the spring, but simply its force, and consequently its inflexion, or, which is the same thing, the ascending progression of its force; and, in this case, the balance will make a greater or less number of vibrations in a given time. But if the number of vibrations are given, as also the weight and diameter of the balance, then, in order to obtain isochronism, it will be necessary to change both the length and the force of the springs.

SECOND PROPOSITION.

152. Since the extent to which springs are capable of inflexion diminishes in proportion to the augmentation of their force, it follows that the stronger a hair-spring is, the longer it will also require to be, in order that the ascending progression of its force be suitable for isochronism. If, then, we have a large and heavy balance which is to make quick vibrations, it will require a very long hair-spring, in order that the augmentation of its force be in arithmetical progression; on the contrary, for a small and light balance, which is to make slow vibrations, the hair-spring, in order to be isochronal, ought to be very short; hence it will be possible, even in pocket chronometers or ordinary watches, to obtain isochronal vibrations by the hair-spring. But, although this property is very useful in marine chronometers, in a watch it would be more only an ideal satisfaction than a real perfection; for this property would be destroyed by the friction of the regulator, and above all, by the escapement, etc.*

THIRD PROPOSITION.

153. The force of a hair-spring being given, we can arrive at isochronism without changing its length, but simply by making it wider; for we have just seen that the inflexion augments when the spring is thinner, and that by this means we can make it isochronal (151). But if the spring requires to be stronger, we can accomplish it equally well by making it wider. If, for example, a hair-spring of a given length and thickness is isochronal, and it be desirable to have one four times stronger, it will answer the purpose if it be made four times as wide, and it will be equally isochronal without being longer than the first.

FOURTH PROPOSITION.

154. The ascending progression of the force of one and the same spring will vary according as it is coiled closer or looser, *i. e.*, according as it has a greater or less number of coils, and as these occupy more or less space; for it is evident that, if a spring has but a few large coils, the inflexions taking place little by little, throughout the entire extent of the blade commencing at the centre, they will act as if it were by very unequal levers, and the ascending progression of its force will augment in a greater ratio.

155. If, on the contrary, the same spring is coiled very closely into a great number of coils, the inflexions will take place at more equal levers, and the ascending progression of the force will be in a lesser ratio. Another property of a spring thus closely coiled into a great number of coils is that the oscillations of the balance are thereby much more free, which I have learned by experience.

156. It follows from this proposition that, having two spring blades of the same force and length, if we coil one of them closely into a great number of coils, and the other loosely, with but few coils, these two springs will not equally possess the property to render great and small vibrations of the balance isochronous; the one closely coiled into a great number of coils will be more proper for isochronism.

FIFTH PROPOSITION.

157. If the blade designed to form the spring is not perfectly graduated throughout its length, the ascending progression of the force of the spring will vary according as the blade is stronger or weaker in the centre or outside, etc. If this blade is too strong in the exterior coils, great vibrations will be performed quicker than small ones, and in order to arrive at isochronism it will require to be made weaker outside; but if, on the contrary, it is weaker at the outside than in the centre, the greater vibrations will be slower than small ones; in this case we may find the conditions

* We translate literally. In connection with this passage the reader must bear in mind the date at which the work was written, and the progress which has since been made in the art.

agreeable to isochronism by simply making it shorter.

SIXTH PROPOSITION.

158. Finally, the dimensions and conditions requisite for the isochronism of a spring vary further according to the nature of the steel of which the spring is made, and according to the force or quality of its hardness; for, if the steel is very fine and pure, and its temper very hard, in order that such a spring should have the given force, it will require to be thinner, and consequently the extent to which it is capable of inflexion will be increased; and to be isochronal, it will admit of being shorter than another spring of the same force, having the same length but which was made of an inferior quality of steel, and whose temper was less hard. From this we see how many properties are required to be combined in order to be able to make an excellent hair-spring, and this will be still more apparent when we shall treat of the process of making them.

159. From all the preceding reasonings it follows: 1st, that, in order to easily obtain isochronism, the blade of a spring must be made stronger in the centre than outside, and diminish gradually from the centre out; 2d, that the spring be closely coiled; 3d, that the blade be of sufficient length so as to admit of a greater number of coils, which is a condition favorable to greater and freer vibrations; 4th, that the blade be made of the best steel, and very hard.

Essential qualities which an isochrononal hair-spring requires to possess, in order to produce, by its application to the balance, the greatest quantity of movement, and also that it preserve its properties.

160. When, as we have been enabled to do by the preceding reasoning, we have found the means to give to the hair-spring the property required for isochronism, we have made a great step towards procuring accurate results in the rate of a chronometer; but this is not sufficient; the application of a hair-spring to the balance requires the greatest care, and above all it is necessary that the property of isochronism in a spring be constant. Now, this depends much upon its shape (154), which might change by heat or cold, and also upon the nature of the spring itself, which requires to possess the greatest possible elasticity without losing it.

161. A comparison of the duration of the motion of two balances serves to estimate their respective forces. Now, the conditions upon which the regulation of a chronometer may be endowed with this essential property, that of preserving its motion for a long time without renewed impulse, are not only to be sought for in the dimensions of the balance, and, in general, in the reduction of friction, but, which contributes still more to the augmentation of its force, also in the proper application of the spring to the balance, and in the nature of the spring itself, so that it is possible, in a given balance, to change its force or the duration of its motion considerably by a more or less perfect spring, although its vibrations may be of the same duration. Whence it is apparent that the choice of an excellent spring and its application to the balance is of some consequence; for, the longer a balance will preserve its free motion, the less the friction of the train, etc., will influence and disturb the isochronism of its vibrations. We shall endeavor in this article to search for the means of making an excellent spring, and apply it to the balance so that it shall be in a state of perfect liberty.

1st. Bodies which are the hardest are the most elastic; accordingly, a spring will make a much greater number of vibrations, as the material of which it is made is the hardest. A hair-spring made of excellent steel, and which is made very hard, will produce in a free balance a motion of much greater duration, and such a spring will constantly preserve its elastic force, and replace the one which was employed to make it vibrate.

162. 2d. In order that the action of the hair-spring be communicated to the balance without loss, and without causing any friction to the pivots of the balance, it is necessary that the vibrations of the spring should not displace the pivots of the balance.

163. In order that the hair-spring be endowed with this property, it must be very long, must have a great number of coils closely wound, and be of a small diameter; in such a case it will have a common centre of motion, and the duration of the motion of the balance will be greater.

164. 3d. The axis of the balance and that of the spring must perfectly coincide.

165. 4th. It is necessary that the spring, when adapted to the balance (this being at rest), be in a perfectly free state.

166. 5th. That the interior end of the spring be very firmly and nicely fastened to the collet, so that, being concentric * to the axis of the balance, it will move as a true spiral, and all its coils in the same plane.

167. 6th. That the stud which holds the exterior end of the spring be very firm, and yet produce no undue strain upon it.

168. 7th. That the regulator pins be solid, so as not to be moved by the vibrations of the spring between them.

169. 8th. The nature of the steel of which a spring is to be made is one of the first conditions which will lead to the proposed object the finest and purest steel ought to be used, such as cast steel.

170. It is not enough to have good steel, it is also necessary to know how to use it, and particularly to forge it with precaution without altering its quality; in forging steel, particularly by beating it cold, its pores are closed, etc.

171. It is by the process of hardening that we are able to give to springs their greatest elasticity; now, the harder a spring is, the more elastic will it be; therefore we ought not to reduce the temper of a spring more than is necessary to be able to coil it without breaking it; for a hair-spring is not exposed to such an extent of tension in its office as the main spring of a watch †; once coiled, it can never break by vibrating.

172. We can, therefore, use a blade of a much greater degree of hardness to make a hair-spring than that of main springs; the only difficulty remains in coiling it and fixing permanently its figure. We shall here give the principles which we have established to accomplish this end.

* A hair-spring is concentric to the axis of the balance when its coils continually bisect, and never coincide with circles drawn from the centre of the balance.

† Main springs are exposed to breaking because that during their action thay are almost always in a forced state.

Principles serving to give to a spring a spiral form, and to cause it to preserve this form.

FIRST PROPOSITION.

173. If we suspend a heavy weight to a very thin steel wire, and in this state allow it to be exposed to a considerable degree of heat, the wire will expand by a greater quantity than it would if it were not charged with a weight for the heat in separating the particles of matter necessarily weakens the wire, and the great weight tends to separate them still more.

If we afterwards expose the same wire to the temperature in which it was before heating it, the action of the cold will not be sufficient to drive the particles of matter in the wire together again; these particles, not consisting of a great enough quantity, and the weight hindering the perfect contraction, the wire will remain longer, and have less force than before the experiment.

174. The same thing will happen if instead of a wire and a weight, we suppose a spring under great tension to be exposed to the heat. The force which holds the spring under tension will have the same effect upon this spring as the weight had upon the wire, *i. e.*, that the extension of the spring will be greater when so under tension than it would have been if it had not been subjected to such a forced state. Thus the effect produced by the cold will not be sufficient to give to the spring the same force which it had before; hence, a spring continually exposed to a forced state loses a portion of its elastic force, and the reason of this is due to the expansion caused by heat.

175. If we increase the tension of the spring so that it shall be of the same degree as before the preceding experiment, and then expose it in the same manner to heat, the spring will again lose a degree of its force; and if we continue to increase its tension in the measure as it loses force, it will in time lose a considerable quantity of its elasticity.

SECOND PROPOSITION.

176. If we suppose the same spring in its first state, but with a weight attached to one of its extremities, and if we give to the spring and the weight it carries a vibratory motion, so that it shall oscillate from side to side by quick vibrations, and if we then expose the spring in

this state to a heat similar to that in the preceding experiment, it will not expand by a greater quantity than if it did not carry any weight, for the continual reaction of the spring will counteract the effect of the weight; and if we afterwards expose this spring to cold, the action of the cold will return to the spring the force which it lost by the heat.

177. It follows from the first proposition that, if we make a chronometer, the spring of which takes a long time to develop itself, this spring will remain a long time under the same tension, and will suffer sensibly the same effect as if it were at rest; thus, in being for a long time in the same situation, it will be exposed to various changes of temperature, which will diminish its force (174).

178. It follows from the second proposition that the hairspring of a chronometer will suffer no diminution in its force than that which is caused by the friction of the particles of which it is composed, and if heat expands it by a certain quantity, cold will contract it and always reduce it to the same state, and that the opposition of the weight of the balance is no obstacle to this.

179. All springs do not lose equally of their elastic force, though they may suffer the same degree of tension. This difference depends upon the nature of the material of the springs, and upon the degree of hardness of the particles which compose them. Thus, steel whose pores are fine and close, when well hardened, will lose less of its elastic force. It is true that the closer the pores of steel are, and the harder it is, the more it is subject to breaking when exposed to cold; but this consideration is of little moment in the case of a hair-spring; for, when it is coiled, even though it were of the hardest temper, it could never break by the action of its oscillations alone, without some accident or foreign cause.

180. The principles which we have just established serve to prove that a hair-spring does not lose its elastic force, supposing its figure constant; but that, above all, has served us as a base for coiling hair-springs hard, in giving them a very equal spiral former; this will also serve us as a guide to permanently fix the figures of the spiral so that it shall not suffer any changes in passing through different temperatures. According to what we have just established, we see that, if we wind the blade of a spring around an arbor, and in this state hold it and heat it even without causing it to change color, then plunge it into oil, this blade, before straight, will assume a very equal spiral form, and its coils will be closer in proportion as the blade has been heated more. This has served as a base of the method of which I have very advantageously made use of to make some excellent hair-springs.

181. A spring thus coiled, is necessarily in a forced state, so that, if it is subjected to a certain degree of heat, the expansion of the particles of the spring will cause it to open or uncoil. In order, then, to bring its figure into a constant state, it is only necessary to heat it after it is coiled and free, by a degree of heat above that to which a chronometer can ever be subject to in different temperatures; this will cause it to open a little, but, inasmuch as it will never be subjected to a greater heat, its shape will remain the same.

182. This, then, is a method for making the figure of the spiral unalterable, that of heating the spring after it has been coiled, sufficiently to cause it to open a little; but a surer and still more preferable one is, to harden the springs after they have been coiled.

[TO BE CONTINUED.]

Experiments Showing the Difference in Temperature at Opposite Ends of a Pendulum.

The amount of the variation in the temperature of the atmosphere which surrounds the opposite ends of a pendulum, has for a considerable length of time been a subject of discussion in these pages, and in order to determine the actual amount of the difference that usually exists, we invited our readers, interested in the subject, to try the experiment in the various localities in which they were situated, and send extracts of the results they obtained to us for publication, and the following tables are a selection from the returns we have received. We find that it is entirely unnecessary to occupy space for the publication of the entire experiments, as all the results point in one direction, and those of our friends whose reports are curtailed, or not published, will observe, on comparison with these tables, that the results

are substantially the same as their own in all cases.

The following are the observations of Mr. Charles Spitzka, 71 Third avenue, New York, from August 6 to January 5. The experiment was tried in a room 18 feet by 20, with ceiling 8 feet high, and in winter the room is heated by a stove. Thermometers placed inside of a regulator case, near to the top and bottom of the pendulum :—

	LOWER THERMOMETER.			UPPER THERMOMETER.		
	8 A. M.	3 P. M.	9 P. M.	8 A. M.	3 P. M	9 P. M.
Aug. 6	..	..	77	..	..	79
7	75	79	79.5	77	81	82
8	76	80	80.5	77½	82	82.5
9	76.5	80	80	78	82	82
10	77	80	81	78.5	82	83
11	78.5	78	79	80	80	80
12	78	82.5	81.5	80	84	83.5
13	79.5	81.5	84	81	83.5	86
14	80	84	84.5	82	86	87
15	81	84	82	82	86	84
16	81	79	80	81	80	82
17	79	82	82.5	80	84	85
18	80	79.5	80	81	81	82
19	79.5	82.5	84	81	84	86.5
20	81.5	81.5	81	83	83	83
21	80	81	81.5	81	82	84
22	80.5	84.5	83	81.5	86	85
23	78	81.5	82.5	80	83	84.5
24	79	80.5	81	80.5	82	84
25	79	78.5	78.5	80	80	80
26	77.5	80	81	78.5	81	83
27	79	81	80	80	82	82
28	75	76	76	76	77	78
29	75	73.5	72	76	74.5	73.5
30	72	73.5	70.5	73	74	72
31	68	69	68.5	69	70	70
Sept. 1	68	69	71	68	70	72
2	70	75	73	71	76.5	75
3	67.5	68	68	69.5	69	70.5
4	64.5	67	68	65	68	70
5	67	68.5	69	68	69	71.5
6	69	71	73	70	72	75
7	72	75	75.5	73	76	78
8	74.5	75	76	76	77	78
9	76	80	74.5	78	82	79.5
10	75	72	73.5	77	73.5	76
11	72	73	74	73	74	76
12	73	75	76	74	77	78
13	75	74	76	75	75	79
14	70	70.5	71	72	72	73
15	69.5	69.5	69	70	70	69.5
16	67	65.5	68	68	66	69.5
17	66	67	69.5	66	68	71.5
18	67	69	70.5	68	70	72
19	69	69	68	69	70	70
20	65.5	67.5	67	64.5	68	69
21	63.5	69	72	64.5	71	74
22	68.5	68.5	69	68.5	70	71
23	70	75	75	71	77	78
24	72	72.5	72.5	73.5	74	75
25	71.5	72	74.5	73	73	76.5
26	71.5	72	72	72.5	73	74
27	71	72	72	72	74	75
28	66	67	68	68	68	70
29	67	68	68	68	68.5	68
30	67.5	69	69	68	70	72
Oct. 1	68	67.5	68	68.5	68	70
2	64	64.5	66	65	65	69.5
3	64	64	68	65	65	70
4	64	67	67	65	69	70.5
5	65	69	68	65.5	67	72

	LOWER THERMOMETER.			UPPER THERMOMETER.		
	8 A. M.	3 P. M.	9 P. M.	8 A. M.	3 P. M	9 P. M.
Oct. 6	67	67	68	68	68	69
7	68	71	71	69	74	74.5
8	68	67	67	69.5	68.5	70
9	63	65	68	65	66	72
10	65	69	67	66	71	71
11	61	66	65	63	68	68.5
12	59	65	65	61	67	69
13	61	61	60	62	61.5	61
14	57.5	60.5	61.5	59	61	65
15	57.5	61	62	59	62	66
16	59.5	62	65	61	63	69
17	58	64	64.5	59	64	68.5
18	63	61	64	64	63	68
19	61	62.5	66	61.5	63	71
20	57	57	57	58	58	58
21	56	68	65	56	70	68
22	60.5	63.5	66	61.5	65	70
23	63.5	64.5	66	65	66	70
24	61.5	63	63	63	64	67
25	62	63	64	63	64.5	68
26	64	64	65	64	66	69.5
27	62	63	62.5	64	64	63.5
28	61	65	66	62	67.5	70
29	59	62	58	61	65	60
30	58	64	62	60	66	68.5
31	59	63	64	61	65.5	69
Nov. 1	59	64.5	65.5	60.5	68	70
2	58.5	63	65.5	61	66	71
3	61	59	58.5	62	59.5	60
4	56	66	67	58	69	72
5	57.5	64.5	68	60	67.5	71
6	61	68.5	68	63	72	73
7	63	64.5	68	65	66.5	74
8	59	66	69	61	70	74
9	58	66	65	60.5	70	70
10	57	57	57	59	58	58.5
11	55.5	63	66	57	66	70.5
12	62	63.5	66	63.5	65	70
13	57	65.5	67	59	68	72
14	60	66	65	62	70	70
15	56	64	64.5	59	68	70
16	53	60.5	65	55	68	71
17	50	50	50	52	51	51
18	48	60	56	49	63	60
19	50.5	61	63	52.5	65	68
20	55	62	64.5	57	66	70.5
21	56	62.5	61.5	60	68	68
22	52	61	63.5	54	65	68.5
23	51.5	61	64.5	54	64.5	71
24	54.5	56.5	56	56	59	57
25	58	61	65	58	63	70
26	56	64	64.5	58	66	70
27	53	61	64	56	64.5	70
28	50	60.5	57.5	53	64	60
29	49	59	59	51.5	64	65
30	41	58	59	44	65	65
Dec. 1	40.5	45.5	44	42	47	45
2	44.5	64	62	46	68	68.5
3	50.5	60	61.5	53	64	68
4	50.5	60.5	61	53	65	66
5	49.5	64	62	52.5	68	69
6	51	52	63	54	55	69
7	51	61	62.5	55	65	69
8	53	53	52	55	54	53.5
9	50	61	59	52	65	66
10	59.5	58.5	58.5	42.5	65	64.5
11	42.5	60	59.5	45	65	65
12	46	59	59	49	65	67
13	44	58	60.5	47	63	67
14	49	61	62	52	68	69
15	51	50	48.5	53	50.5	50
16	48	54	63	50	59.5	69
17	50.5	62	63.5	54	67	70
18	51	62.5	63.5	55	68	70
19	51	61	64	54	65	70
20	53	63	64.5	55	68	71
21	53	60	63	57	65	70
22	45	43	41	47	46	43
23	36.5	57.5	58	38	63.5	65

The following observations were made by Mr. Spitzka in a position in his house where the ceiling was equal to 20 feet high. The same thermometers were used as in the last experiments, and they were suspended in the open room, one about 40 inches above the other:—

	LOWER THERMOMETER.			UPPER THERMOMETER.		
	7 A. M	3 P. M	9 P. M.	7 A. M.	3 P. M.	9 P M.
Dec. 24	41.5	60	58.5	43	68	68.5
25	36.5	41	37	39.5	44.5	38 5
26	34	53.5	49.5	36	59.5	55
27	35	51	50	38	56	57
28	38	52.5	49	41	58	56
29	40.5	38.5	38	42.5	40	39.5
30	35	50	51	37	56	58
31	45	60	61	48	66	68 5
Jan. 1	46	43.5	42	48.5	46	43 5
2	40.5	59	58	43	66	64
3	49	59 5	51	52	64	54
4	46	58	61	48	66	68
5	49	49	47	51	50.5	49

Joseph Sterling, Leavenworth, Kansas, observer; ceiling of room 12 feet high and heated with a stove. Thermometers suspended inside of a tall regulator case, one at each end of the pendulum:—

	LOWER THRMOMETER.			UPPER THERMOMETER.		
	7:30 A. M.	2 P. M.	6 P. M.	7:30 A. M.	2 P M.	6 P. M.
Nov. 1	60	..	66	61	..	68
2	60	65	..	62	67	..
3	58	..	66	59	..	68
5	66	..	68	68	..	66
6	..	..	69	..	..	67
7	61	64	..	63	66	..
8	60	..	..	61	..	..
9	..	..	66	..	..	69
10	61	..	..	62	..	..
11	53	..	68	55	..	65
12	..	..	57	..	..	59
13	..	64	65	..	67	67
14	48	..	..	51	..	..
15	51	..	..	53	..	..
16	52	..	..	54	..	..
18	46	59	..	48	61	..
20	53	..	..	55	..	..
22	58	..	..	60	.	..
23	52	62	..	59	64	..
25	50	..	..	52	..	..
26	54	..	..	56	..	..
27	51	..	..	53	..	..
28	55	..	..	56	..	..
29	45	..	..	47	..	..
30	51	..	..	53	..	..
Dec. 2	48	..	58	50	..	61
3	50	..	..	52	..	..
4	53	..	..	55	..	..
5	..	62	..	..	64	..
6	53	..	..	56	..	..
7	55	..	67	57	..	70
8	54	..	..	56	..	..
10	..	..	63	..	..	65
12	51	..	..	53	..	..
13	46	..	..	48	..	..
16	47	..	..	49	..	..
18	50	..	..	52	..	..
20	46	..	..	49	..	..
21	48	..	..	51	..	..
23	40	..	..	43	..	..
27	41	..	..	44	..	..
28	35	..	..	37	..	..
30	43	..	..	45	..	..
Jan. 1	47	..	..	50	..	..
6	42	..	..	45	..	..
10	52	..	..	55	..	
13	53	..	65	56	..	68
14	..	..	64	..	..	66
15	44	..	..	47	..	..
17	48	..	..	50	..	..
19	..		59	..	..	62
20	48	..	50	..	..	.

The following results were obtained in a large room in Mr. G. Autenrieth's factory, Long Island City, observer, Wm. Preusser; room 50 feet by 35, height of ceiling 12 feet; room heated by coils of steam pipes on two sides of the apartment; thermometers placed in the inside of a clock case at the opposite ends of the pendulum; clock stood about 6 feet from the the steam-pipes:—

	LOWER THERMOMETER.			UPPER THERMOMETER.		
	7 A. M.	12½P.M.	6 P M.	7 A. M.	12½P.M.	6 P. M.
Jan. 13	49	65.5	71	50 75	68	72 5
14	52	65	67.5	53 5	67	71
15	54.5	64.5	70	56	64.5	71.5
16	58	55.5	55.5	58.5	58	57.5
17	41.5	65	66.5	43	67	68.5
18	48	67	70	49.75	69	72

Mr. Theo. Gribi, Wilmington, Del., made the following observations: Room small, but well ventilated. Height of the ceiling ten feet from the floor. Height of freezing point of the lower thermometer from the floor, four feet six inches. Height of the upper thermometer exactly the length of a seconds pendulum above the lower one:—

	LOWER THERMOMETER.			UPPER THERMOMETER.		
	8 A. M.	Noon.	8 P. M.	8 A. M.	Noon.	8 P M.
Dec. 29	56	59	66	64	66	74
30	53	61	66	59.5	70	77
31	60	67	68	66.5	73.5	76
Jan. 1	65	64.5	67	73	70	72
2	62	63	66	68	69	72
3	66	62.5	69	71	69	79
4	66	63	66	72	68.5	73
5	65	63	68	71	69	75
6	63	64	64	68	70.5	72
7	62	65.5	66	67	70.5	73.5

The following are the results of one week's trial of the experiment in the office of this Journal.

The room is about 14 feet by 30, and the height of the ceiling about 11 feet. The room is heated by an open stove, and the thermometers were suspended in the open air about 12 feet from the stove, the lower thermometer being about 3 feet from the floor, and the upper thermometer 40 inches higher up:—

	LOWER THERMOMETER.			UPPER THERMOMETER.		
	10 A. M.	1 P. M.	4 P. M.	10 A. M.	1 P. M.	4 P. M.
Feb. 22	64	65	65	69	68	66
24	59	61	63	63	65	65
25	59	61	61	63	65	66
26	59	61	61	64	65	66
27	61	65	64	64	68	66
28	62	65	65	63	68	67

Mr. B. F. Hope, of Sag Harbor, near the easterly end of Long Island, and in close proximity to the Atlantic Ocean, writes us as follows: "The experiments in regard to the temperature have had my attention for over a year, and the results obtained have much surprised me. My shop is 36 feet by 18 feet, and 11 feet high. It is built of brick, is detached on one side, and is, therefore, exposed to the cold on that side. My clock stands 20 feet from a 14-inch cylinder stove. There is about 20 feet of stove pipe within 18 inches of the ceiling, but none of it is nearer the clock than the stove is. The clock case is made of iron and glass, with a solid mahogany back. In summer, and at all times when the temperature is above 40 degrees outdoors, the thermometers at the top and bottom of the pendulum differ from one to three degrees only, varying as the amount of artificial heat is increased or lessened. When the temperature is from 20 to 40 degrees outdoors, the difference in the thermometers inside varies from 3 to 7 degrees, still varying according to the quantity of artificial heat. From zero to 20 degrees outdoors, the difference in the thermometers inside is from 7 to 15 degrees. On the morning of the 30th January, from 8 to 9 o'clock, the inside upper thermometer marked 70°, and the lower one 55°, and outside the thermometer was but 2° or 3 degrees above zero. All the rest of the day and the day before, the difference which existed between the inside thermometer was from 8 to 10 degrees. The average difference is rather less when the thermometers are placed inside the clock-case, but not much. In the morning, before the fire is made, there is but one or two degrees of difference in the thermometers. My experiments were carefully conducted, the thermometers being repeatedly changed from one position to the other."

The above tables and observations give conclusive evidence that in rooms which are heated by artificial means, there exists in many instances a considerable difference in the temperature of the atmosphere which surrounds the top and bottom of a pendulum; and, what is of especial importance to those seeking to improve the compensation of pendulums, is the fact that the variation is not regular, but varies in the most subtle and uncertain manner. It remains to be demonstrated whether it is possible to construct a pendulum that will counteract these evils without creating others which have as bad or a worse effect on the rate of the clock. We incline to the opinion that the difficulty will eventually be overcome, and that many of the errors incident to existing compensating pendulums will, if not entirely overcome, be considerably reduced.

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Watch Repairing.—No. 9.

BY JAMES FRICKER, AMERICUS, GA.

The escapement is recognized by all Horologists as being the most important part of any time-keeping machine, and when a good workman has a watch placed in his hands for repairs, he gives particular attention to the escapement, well knowing that a little defect or disarrangement of any of its parts would cause the watch to stop, or make it perform very irregularly; whereas the same amount of discrepancy located in any other part of the watch might not affect its time-keeping qualities at all. The escapement is, by the majority of workmen, but little understood. This seems like a broad assertion, but how many are there who will read this article that can explain to an apprentice, for instance, the principles of a lever

escapement; or, if a given escapement does not perform as it should, can point out the defect and administer the remedy, or who could by any possibility, make a correct drawing of a good working lever escapement?

We propose to point out some of the more common defects of the escapement met with in repairing the lever watch, and to give the remedy. One very frequent cause of a watch performing badly is to be found in the escape-wheel. The teeth become worn on the points (we are now speaking of a sharp-toothed wheel), which makes the wheel too small. The only remedy for this is a new wheel. Never try to hammer the teeth so as to make them longer; or, what is worse if anything, never bend the teeth back.

Before taking the watch apart, and while there is power exerted on the escapement, remove the balance; then, with a piece of peg-wood or other convenient article, try the escapement, by placing the point of peg-wood in the notch of the lever and very slowly moving it until the tooth of scape-wheel passes from the *locking* face of the pallet arm, to and over the *impulse* face, when the other arm of the pallets will lock the tooth of the wheel opposite to it, provided the escapement is correct. If the teeth of the wheel are worn much, or the corners of the pallet jewels are either worn or broken, instead of the wheel becoming locked, the tooth that ought to become locked will fall upon the impulse face of the pallet jewel and drive the lever back the other way. Sometimes this will be noticed in one arm of the pallet and then again in both. If the pivots of the scape-wheel or pallet staff are badly worn, or the holes too large for the pivots, either from wear or from having been made so by incompetent or careless workmen, the same effect will be noticed sometimes. In examining the escapement try the "side shakes," and carefully examine the pivots and holes to see if they are round and true. As before stated, if the fault is in the wheel, a new wheel must be put in.

Select a new wheel, a very little larger than the old one, exercising some judgment, so as not to get it too large; stone it down (using a sharp fine file first) if very thick, to about the right thickness; then, with a scratch-brush, clean off the burr formed by the stone, cement the wheel up on the lathe, true it up by the outside of the teeth and bore out the holes in the centre to the proper size, take it down, boil out, and then polish it on a piece of "touch-stone" or agate which has been ground with fine diamond powder, and another stone acting as a grinder. A stone prepared in this way will put a beautiful polish on a brass wheel in a few moments.

If a new collet is required for the scape-wheel, put a piece of brass wire in the lathe and drill a hole a little smaller than the staff of the scape pinion, and turn it up to a proper shape on the end; cut off and broach out the hole to the right size, and then drive it on the scape pinion. Cement the pinion up in the lathe and proceed to fit on the scape-wheel and burnish it on tight. By fitting it on in this way it will be perfectly true. If the wheel is a little too large, again put it up in the lathe, and grind the points of the teeth down slightly with a piece of fine Arkansas stone, lubricated with oil; or grind it down by any of the processes recommended in former numbers of the JOURNAL. If the pallet stones are either broken or badly worn, either put in new stones, or, if permissible, draw the old ones a little, and grind and polish them down to the proper shape and dimensions. In putting in a new stone, lap down a piece of garnet or chrysolite to the proper thickness, give it a rough shape, cement it into the slit in the end of the pallet arm, and grind it down almost to the steel, and then polish, using a brass or copper lap for all but the final polish, which is given with boxwood and diamond powder. The copper laps or mills can be made out of old copper one-cent pieces, and faced up, and charged with diamond powder. One carat of diamond powder will last a watchmaker from five to ten years, and no one who has once used it, will ever consent to do without it. In polishing a stone with diamond powder, it will be necessary to examine it with a double eye-glass, to see if it is perfectly smooth and polished; if it is not, the ends of the teeth of the scape-wheel will be ground off in a short time after the watch has been in use.

In putting on a new scape-wheel, always be particular to see if the teeth will pass fully underneath the lever or fork. The notch in the end of the lever should be straight and well

polished inside, and just enough larger than the roller jewel to allow it to work freely, and no larger. The roller jewel should always be flattened on one side, towards the pallet staff; then the unlocking can be done with much less lost motion, or useless expenditure of power, than with a perfectly round roller jewel. In putting in a new roller jewel, select one that will work freely in the notch of the fork, and have but very little play; in fact it must have just as little play as possible, and still be perfectly free. To flatten one side of the roller jewel requires two diamond laps or mills, one charged with diamond powder coarse enough to grind the jewel down sufficiently, and the other one charged with fine diamond powder for polishing.

Having selected a jewel, and put the lap in the lathe, take a small cork, wet the end of it on the tongue, then press it down on the jewel, when you will find the jewel sticking to the cork. Next wet the lap, and, with the jewel on the end of the cork, press it against the face of the lap and start the lathe, moving the cork all the time while the lathe is running. Stop the lathe before attempting to remove the cork, or you may lose the jewel; then slide the cork off the lap to one side, and you will see the jewel imbedded in the end of the cork. If the jewel is ground sufficiently, about one-third of its thickness requiring to be ground away, rub the end of the cork having the jewel on it, on a piece of letter paper, which will remove the dirt, etc., and still leave the jewel on the cork; put in your polishing lap, and this time lubricate with oil, and proceed as with the first lap. To ascertain if the "flat" is polished, wipe on a piece of paper as before, then see if it has the required polish. Clean the jewel with alcohol, and then cement it in the roller with shellac. If the roller is very thin, or the jewel fits it rather loosely, file up a brass pin the size of the hole, then file away two-thirds of its thickness; put in the jewel, then wedge it in with the brass pin, cut off neatly, and a very little shellac will hold it in firmly, and then clean off all superfluous shellac from the roller.

Never let a watch that you have repaired be put into its case until you have examined the banking, ticking, etc. With the movement in your left hand, carry the balance around so that the roller jewel is free from the fork, then with the tweezers push the lever back so that the guard pin will rest against the roller, when on turning it loose (supposing of course that you have some power on the train) the lever will fall, or be driven rather, back against the banking pin; then turn the balance so as try the other side. If the guard pin is bent too far back, and the scape-wheel, pallets, etc., are all good and perfect, you will find that the guard pin will remain against the roller, in trying it this way, from the fact that the tooth of the scape-wheel will pass over from the locking face of the pallet jewel to the impulse face of the same; in which event you must bend the guard pin a little towards the roller. If the banking pins are too far apart, the roller jewel will strike against the prong of the fork on entering; if too close together, it will strike against the side of the notch in passing out.

As it will be impossible to explain several points about the escapement without drawings, we will drop the matter just here until some future time. As soon as time and business will permit, however, we will resume this subject, and give such diagrams as will make the escapement more fully understood by the unscientific than it is now. The readers of the Journal will please be kind enough to overlook grammatical errors, and the want of that systematic arrangement of ideas that should have been observed in these articles, as we are compelled to write during business hours, and frequently have to drop the pen in the middle of a sentence to attend on a customer, or explain something to an apprentice; and but for the interest we take in Horological matters, and the desire to see the Journal firmly established as the representative organ of the trade, and not simply an advertising sheet gotten up by some one to enable them to sell their wares, we would not have attempted to write a series of articles at this time. We also wish to tender our sincere thanks to those of the trade who have, by letter to the writer, and through the columns of the Journal, kindly complimented us on our feeble efforts to contribute our mite to Horological literature. These compliments, coming from those who are personally unknown, make us feel more than grateful.

Excessive Sweating—(Hyperidrosis).

We have frequently heard watchmakers complain of great annoyance from profuse perspiration of the hands, and have requested an esteemed medical friend to give the latest information on the subject of excessive local perspiration, and the most successful methods of treatment.

Hyperidrosis, or excessive sweating, from the Greek ὑπέρ in excess and ἵδρωσις sweating, may be general or local. The predisposing causes of this affection are quite unknown; we notice, however, those subject to it are often of a plethoric habit. As a consequence of excessive sweating, we find in some people that a slight eruption called "suadamina" is readily produced, whilst in others the hyperidrosis may continue for years without producing any perceptible changes in the skin. The treatment of *general* hyperidrosis is only palliative. It is important to avoid warm baths, to change the under linen frequently, and to sponge the body from time to time with a lotion, consisting of two drachms (*i. e.* two teaspoofuls) of dilute sulphuric acid to a pint of water.

The skin should be kept constantly powdered with starch or finely powdered asbestos. The following lotion will sometimes be found useful:—

℞ Acidi Carbolici	ʒ i.
Alcohol } Glycerini }	℥ i.
Aquæ	℥ vi.

Mix, and use as a lotion night and morning.

Local hyperidrosis is most common in the skin of the head, arm-pit, hands, or feet. Occasionally cases are met with in which the sweating is strictly confined to one lateral half of the head or body; these cases are without doubt distinctly due to a morbid state of innervation—*i. e.* the nervous influence in that part of the skin is deranged—and should be treated by the local application of belladonna liniment.

Local (*i. e.* partial) hyperidrosis of the arm-pit, often gives rise to the skin disease called eczema, while in the hands and feet the cuticle may be macerated, softened, and partially peeled- off; the skin thus denuded becomes very tender.

In most forms of hyperidrosis general remedies are useless; the treatment must be entirely local. In ordinary cases the parts should be frequently rubbed with a lotion consisting of a drachm of tannic acid to six ounces of spirits of wine, or eau de Cologne; each application should be followed by starch or asbestos powdering. If this fails, the belladona liniment should be tried. Hebra, the celebrated dermatologist of Vienna, in Austria, recommends, in severe cases of sweating hands or feet, the following procedure, which he says never fails. A certain quantity of the simple diachylon plaster is to be melted over a gentle fire, and an equal weight or a sufficient quantity of linseed oil is then to be incorporated with it, the product being stirred till a homogeneous mass is produced, sufficiently adhesive not to crumble to pieces. This is then to be spread over a piece of linen measuring about twelve inches square. The foot of the patient, having been first well washed and thoroughly dried, is now to be wrapped in the dressing thus prepared. Pledgets of lint or cotton, covered with the same ointment, are to be put between the toes, to prevent their touching one another, and care must be taken that the foot is completely covered, and that the plaster is accurately in contact with the skin. When this has been done, an ordinary sock or stocking may be put on the foot, and outside this a *new* shoe, which must be light, and should not come above the instep. After twelve hours the plaster is to be removed; the foot must *not* be washed, but must be rubbed with a dry cloth and starch powder or bran. The plaster is then to be renewed and applied in the same way as before, and this must be done every day *twice*, and continued eight or twelve days, according to the severity of the case. During this time, however, the patient need not keep his room, but may go on with his business as usual. At the end of eight or twelve days the plaster and pledgets between the toes are to be removed, and the foot is to be again rubbed with some powdered substance, and the patient may then be allowed to wear his ordinary shoes and stockings. In the course of a few days it will be found that a brownish yellow layer of cuticle is beginning to peel off from all those parts of the skin which were before affected with the disease, and that a healthy, clean white sur-

face of cuticle is exposed as this substance separates.

When this layer of cuticle has become completely detached, the foot may for the first time be washed, but it will still for some time be advisable to dust some powder into the stocking, or to rub it on the skin of the foot. After the lapse of a fortnight or three weeks from the first application of the plaster the hyperidrosis will generally have disappeared, and the cure will last for a year or longer, or may even be permanent. In quite exceptional cases, however, it will be found that a single course of this treatment is not sufficient to effect the complete removal of the complaint. The whole procedure must then be gone through a second time; but this will certainly and without exception bring about a cure.

The above plan of treatment is applicable to the hands as well as the feet—one hand at a time—if the disease is severe enough to make it worth while to submit to the inconvenience. The patient would be deprived of the use of the hand for the time as if the arm was broken.

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Ambiguous Orders.

A very little care on the part of correspondents in giving their orders would save much annoyance and vexation to their receiver, as well as oftentimes a delay and loss of temper to the sender. Publishers are probably less troubled by ambiguous orders than are tradesmen, for the thousands of articles they deal in are all liable to be imperfectly described by correspondents.

A material dealer, for instance, receives this order: "Send also 7 gross flat glasses, assorted sizes." What would he send to meet the wishes of his customer? And yet this is but a single example of the obscurity of orders daily received by dealers in materials and merchandise, and often accompanied by a request to have the goods forwarded at the earliest possible moment. Now what is to be done—either to *guess* at the correspondent's meaning and perhaps send the thing he does not want and have the goods returned by the next express, subject to charges, with an enclosed letter from the indignant party, "blowing him up" for carelessness and stupidity in filling his orders, or, which will quite as seriously anger him, answer his order by asking him to give more specific directions as to what is wanted, and receiving for answer that "he *did* want so and so, but he has now ordered it of other parties who will fill his orders *promptly?*"

All these vexations are easily avoided by a little more care in giving the orders; if the exact technical description is not known, take a little more time and describe what is wished. Instead of ordering "½ doz. wedding rings, assorted sizes about 4 dwt. each," it would be preferable to say "solid 22 K. plain, etc.;" or if in your location, 18 K. are used as *wedding* rings, say "18 K. solid plain, etc." All possible ambiguity of language should be avoided.

In ordering "a gross of hole jewels assorted," how is the dealer to know whether you wish them assorted from English fuzee down to the smallest possible size, or whether you wish the best ruby, or the ordinary quality? and if he assumes that you wish the best, may send them to you at a price which may be so far in excess of what you have been in the habit of paying, you jump at the conclusion that he has overcharged you; and although your civility will not allow you to complain, yet you quietly make up your mind to transfer your patronage to some other dealer. Your correspondent wonders why he never receives any farther orders from you, remaining in total ignorance of the little transaction which diverted to another the trade he did his best to keep. It is very probable that there is no loss to the jobber in the aggregate of all these mistakes, for the losses and gains by each dealer will about counterbalance each other. It is nevertheless vexatious to both parties; one is incommoded by the want of the things ordered, the other greatly annoyed by the occurrence of mistakes over which he had no control.

Want of established standards for measurement, and the lack of *legal* standards for quality, are the fruitful source of many errors of this character. An order for rings of a certain size and quality carries a vast amount of uncertainty on its face. The size may be that used by the party giving and receiving the order; it may be taken from a stick used by only one of the parties, or it may be from "Allen's Standard Ring Gauge," on the supposition that it is

universally used (as it ought to be). The quality is, unfortunately, as indefinite as the size; an 18 karat *mark* means no fixed quality, its range extending from pure *brass* up to $\frac{750}{1000}$ fine, depending both upon the honesty of the manufacturer and the buyer; hence the necessity of explicit directions. In giving all orders always describe fully, if possible, the size, quality, form, color, and quantity; and where there is any possibility of mistake, give explicit shipping directions. Never depend upon the jobber's recollection of how you *usually* ship—for he cannot possibly remember the peculiarities of each of his thousand customers. These little matters properly attended to, the wheels of commerce will roll smoothly on without unpleasant jar or friction.

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The Laws of Nature and Friction.

Ed. Horological Journal:

On page 90 of the present volume Mr. Muma of Hanover, Pa., makes the following remarks: "I will not take part in the friction question, but because 'Clyde,' as an outsider or looker on, sides with the stronger party, I must remind him of the well known fact, that the laws of nature cannot always be followed with advantage." Whatever opinion Mr. Muma may have formed about my being an outsider, taking sides with the stronger party, is of but little consequence; all I would say on that point is that there are many connected with the trade who consider that in this particular Mr. Muma has not proved himself to be a very good guesser.

I have read all Mr. Muma's communications very carefully, and he may think it strange, when I state that I perfectly agree with everything he says on the influence of oil on rubbing surfaces, and also that I do not lose sight of the impossibility of entirely obviating the necessity for the use of some kind of lubrication on nearly all rubbing surfaces. I should have thought that any person who has followed this discussion from the beginning, and carefully read any remarks I have made on this question, could not have failed to comprehend that it is the principles which underlie the action of *clean and dry* surfaces rubbing against each other which my remarks refer to. If we desire to possess an intelligent knowledge of the causes and effects of friction we must study the principles which underlie the subject to the very foundation. Sufficient practical examples have been given to prove every thing I have asserted on the subject, and I have yet to learn that there has been any special dispensation granted that puts a watch outside of the influence of natural laws which govern the motion of the rubbing surfaces of other machines used for purposes either requiring strength or precision.

Mr. Muma's ideas of the laws of nature are not very clearly defined. In writing on different subjects he uses the following expressions concerning these laws. One place he tells us that "they cannot always be followed with advantage," in another place he tells us that "from nature he takes his rule," and again he gives us an example of "getting ahead of nature," and he also tells us "that all man can do in his best direction, is to approach the ideal;" which last remark is unquestionably true. I would respectfully call upon Mr. Muma to inform us in what particular and on what occasions it is beneficial not to follow the laws of nature in everything connected with mechanics. If we find certain results produced when certain conditions are observed, and when these results vary as the conditions vary, whatever the results may be I consider that they are in accordance with the laws of nature in every instance.

I do assure Mr. Muma that I have not thought superficially on any of the questions involved in his watch pocket, which may be good enough in its way, but I cannot admit that on any occasion he gets ahead of nature by the use of it. It is my firm conviction, that when any system of reasoning leads us to suppose that we are getting ahead of nature in the practical results we produce, we may be absolutely certain that the premises we start from are entirely false. If Mr. Muma should decide to favor us with a few more remarks, I would suggest that those on the laws of nature and on watch pockets should be made in separate communications from any remarks he may have to offer on the subject of friction. The friction controversy should not continue to be used as a vehicle for introducing questions which do not strictly belong to it; it has long ago developed itself into a question of reducing

the abstract laws of friction to practice, and I consider the question at issue to be the truth or the fallacy of these laws, and nothing else. From all I can learn from Mr. Muma's communications, his views on the subject of friction are substantially the same as my own, although Mr. Muma appears to think it unnecessary to investigate the subject himself, or that others should do so.

Under the heading of "Friction," we had a communication from Mr. Barnaby, of Marion, Ala., in the March number. Mr. Barnaby inclines to be cynical in his introductory remarks, upon those who have previously participated in this discussion, and desires to present the friction controversy in a "new light," and he has succeeded. His remarks on the sizing and cleaning of mainsprings are true, and would be very proper under another heading; and his other remarks on watch-repairing will doubtless be beneficial to many, although they are a little out of place in this discussion. He recomends that "all the pinions and arbors should be mathematically upright, and the ends and side shakes correct," which is certainly a good and sound advice, but it does not apparently occur to him that when a pinion or an arbor is *mathematically* upright, and the holes proportionably straight, that there is a greater extent of rubbing surface in action than when the arbors are a little off the upright. Yet when they are upright, we all know that they run easier than when they are a little off, even although the holes are sufficiently wide for freedom, and the wheels free of everything. What is the reason of this, Mr. Barnaby? It is questions of this kind we propose to discuss, under the heading of "Friction," and if the "master" you refer to cannot tell us why "this is thus," we propose to try and find it out for ourselves, both for our own benefit and for the benefit of others.

CLYDE.

Motor vs. Friction Isochronism.

ED. HOROLOGICAL JOURNAL:

This article only refers to "going barrel" watches (where the isochronal property of the spring is employed as a substitute for the fuzee), for the purpose of making the subject of isochronism easier understood, and prove that the fuzee is equivalent to half the isochronism of a watch, to those who are not in the theory. Not to distinguish between necessary obstacles to time measure, and unnecessary ones, is now a relic of the past. When a cause of error can be easily removed or avoided, it is not necessary to use it, and no effect requires to be counteracted. In a watch escapement, as well as in many other things, the "ounce of prevention" is worth what is claimed for it. One of these is the variable pressure against the detent, because it can be avoided by the use of the fuzee, and the isochronal property of the pendulum spring can be made a corrector of the effects of variable resistances to the motion of the balance, as well as of those from altered motive force. In other words, if we can make this property cover the effects of many necessary causes of variation, we are inconsistent if we sacrifice it for the purpose of counteracting the effect of a single unnecessary one, and permit all the others to put their effects in force. Thus, what compensation is to the effect of variable temperature, friction isochronism is to the effects of variable resistance to the motion of the balance, from whatever cause, whether decreased resistance through the lift pallet or jewel pin, altered position of the watch, shape or external motion of any (in a certain kind of escapement) kind, cold oil, etc. Although the isochronal property of the spring was not appreciated for a long time, when the chronometer escapement was invented, its isochronism was appreciated too much. It was then "only necessary to make the spring isochronal, which was known when the vibrations of the balance were made in equal time, per unequal motive force." It was not discovered that the isochronal vibrations were made by a non-isochronal spring; that, per larger pressure against the detent, the spring gained (or would if it were not opposed by the losing tendency in the inexorable escapement) in larger tension. This is not all; it is not to this day realized by the greatest masters of the art, if I may judge from their writings on the very important subject of isochronism. They seem to persist in the idea that the spring is isochronal when, in variable motor, the balance makes isochronal vibrations. From this view of the matter, however, no correct deductions will ever

be made. It is true, the spring is independent of the mainspring, but it is not true that it is independent of the latter's resisting influence, and cannot be. Pressure is no impelling force or impulse without distance, but it is a resisting power without distance. No escapement can be quite isochronal for these reasons direct. Although the principle of the chronometer escapement loses in larger motive force from necessity, as above explained, it is much nearer isochronal than the principle of the lever escapement. Thus, according to this loss in an escapement, must the spring be distorted from its natural isochronism, if it is to make the motive force in effect equal. This being achieved, the watch either gains or loses (larger tension gains, smaller tension loses) in all cases where the tension alters per same pressure on the detent from whatever cause or combination of causes. By far the most effective and defiant cause of larger tension is the continual easier slip in the detent, not only from wear where there is no metal to spare, but also from the greater necessity for constancy, under the circumstances. Thus, were the hold on the detent face in a new motor isochronal going barrel lever watch, represented by 100, and remained 100, it would simply do its duty in the same way that the hair-spring does its duty when it retains its elasticity; but it first reduces to 99, and then to 98, and so on all the time the watch is going.

Antagonism is at the bottom of all correct time measure. Nature only employs the opposition between the pendulum-spring and the balance or fly-wheel, in the form of gravity and the centrifugal force; but does not use a motive force, and the antagonism ends with the above regulator. But, because man employs a motor in combination with the regulator (spring harnessed to a fly-wheel), he brings into power this antagonism number two, which is the subject of this article, viz.: that between the spring and the mainspring, and therefore has to contend with two primitive sources of error in rate power, while Nature has to contend with only one, viz.: the antagonism between two "concomitants of greatness" (gravity and its balance), which require no impulse, the same as when a watch balance has no friction, were it possible. Now, the deduction is this: the chronometer escapement loses less and less in larger pressure against the detent, as it approaches nearer to non-resistance to the motion of the balance. This is one reason why one chronometer maker excels another—he has a few correct ideas; how he got them, nobody knows; certainly not from experimenting. Nothing can be known in this way that is worth much, because it is similar to experimenting with colors on a canvas—a picture cannot even be copied, for the same reasons that a watch cannot be copied; although the world is full of experimenters in both these arts; and very little is done where the mind does not go before. The merit of men may be known by the degree of development of this hobby.

J. Muma.

Hanover, Pa.

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Whiskey vs. Whiskers.

Ed. Horological Journal:

Alas! poor "Pinion," whose face has not felt a razor for 25 years, and who has fought the abomination in season and out of season! Alas! that he should have come to this—that his friend Miller should have been the one to stab him in the dark! On Jan. 1st, "Pinion" wanted a first-class clockmaker; engaged one recommended up among the nineties; thought his nose a little red, and gave a gentle hint; found he had a very bad cold and had taken a drop of whiskey and molasses; first job was watchman's detector; broke both balance pivots, and straightened hair-spring trying to put it together with his fingers; did not know what tweezers were; think it was the first movement he ever saw out of the case. Engaged another, recommended some ways above par. Had always been on fine work—carriage clocks and repeaters a specialty; nose quite red, but had a sister married the week before, and took just a drop to keep the rest company; could not put a Yankee clock movement together, so put him on French; broke one pivot off, and bent nearly all the others in taking movement down. Got desperate! Rushed into the *Herald* office, and "Wanted a clock maker with some brains and *no* whiskey." Printer evidently had more whiskey than brains; got things mixed. Finale! engaged a man with *lots* of brains and

no whiskey, but the finest whiskers in town; at least 12 inches down his breast.

"PINION."

N. Y. City.

Thick and Thin Jewels.

ED. HOROLOGICAL JOURNAL:

I adjusted a watch to position with very thick balance jewels. To do this the pivots were made perfectly flat on the ends. I then readjusted it with very thin balance jewels, rounding the end stones to make the adjustment. It increased the motion of the balance so much that I had to change the mainspring for a weaker one. Will "Clyde" please explain why this was so?

F.

Richfield Springs.

Exhibition of Chronometer, Watch, and Clock-Making.

Prizes will be given to those exhibitors being the producers of the best specimens of work in chronometers, watches, and clocks; also a prize to the inventor of the best tool or contrivance for facilitating the production or improving the quality of work connected with the horological arts.

For the guidance of intending competitors, some of the branches, as below, are specified, but the invitation is offered alike to *every* branch.

Chronometer Escapements,	Hand Making,
Lever Escapements,	Balance-spring Making
Finishing,	Main-spring Making,
Cap Making,	Fuzee Cutting,
Case Making,	Movements and Parts of Movements,
Case Springing,	Pivoting,
Jewelling,	Index Making,
Examining,	Name Engraving,
Compensation Balance,	Engine Turning,
Keyless Work,	Case Engraving,
Wheel Cutting,	Case Enamelling,
Dial Making,	Dial Finishing,
Pallet Making,	Gilding.

Note.—The clock work not to be for larger than ordinary one-second pendulum regulators.

Every piece of work submitted will receive the attention of the judges, the desire being to promote the attainment of perfection in every branch of the art; but no complete time-keeper will be eligible for competition, unless the specific portion is indicated for which merit is claimed.

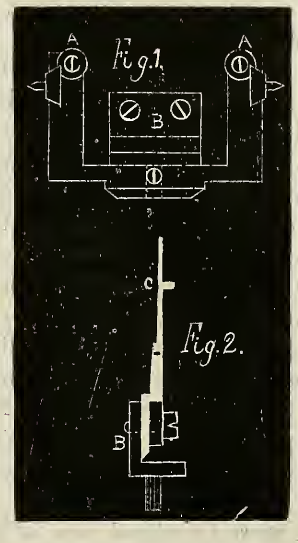
At least £50 will be distributed as prizes.

Three judges will be appointed, one to be named by the exhibitors, one by the Council, and Lady Burdett Coutts will be requested to appoint the third.—*British Horological Journal.*

Polishing Chronometer Detent Shoulders.

We are indebted to the *British Horological Journal* for the following sketch and description of a swing tool for polishing chronometer detent shoulders without removing the spring when once placed in position:

"Figure 1 is an ordinary swing tool with sliding dove-tail centres, which may be acted



upon by the double-headed screws A A, working into notches cut into the ends of dove-tail slips, when it is desired to find the exact centre of the shoulder to be polished.

"The vice or holder B is of brass, of such a height that the top surface is under the line of centres to insure perfect steadiness, and is fixed by a shank turned to fit a hole in the base of the swing tool. Two flat surfaces are filed upon the shank exactly at right angles for the purpose of receiving the point of a set screw.

"Figure 2 shows the holder taken out of the swing tool, but with the detent *c* fixed ready for operating upon. It will be observed that the upright back of the holder is not in a line with the shank, but is filed far enough back to allow the spring to turn on the centre, so that the three parts of the shoulder always swing correctly. A movable clamp with two screws is provided for fixing the detent to the holder.

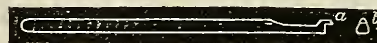
"T. NELSON."

Answers to Correspondents.

L. A. B., *Michigan.*—If you will send the cylinder movement we can have it repaired for you, but if you had acted upon the maxim that the "safest way is the best way," it would have saved you the accident of breaking even such a small cylinder. To drive out the upper (or lower) plug *safely* you ought to have made a stake that would exactly fit it; brass would do for the purpose.

To make this stake, you would have first to make a counter-bore, which is a drill with a "tit" projecting from its centre. This tit must be the diameter of the plug, which is the interior diameter of the cylinder, which you can come at by measuring the outer diameter of the cylinder, then diminishing that amount by the estimated thickness of the cylinder, which will give you its interior diameter near enough for the purpose. The diameter of the drill must equal that of the shoulder over which the hair-spring collet slips. Now drill through a piece of brass a hole the size of the tit of your drill, then run down the counterbore two-thirds the depth of the collet shoulder. Fig. 1 is a vertical sectional view of the stake and hole. It is eminently necessary that these

holes should fit the various parts of the cylinder accurately, for usually in small cylinders the brass shoulder around it is very thin, and the shell of the cylinder itself is also very thin; but however thin it may be, it *must* be supported while the plug is being driven out. It will not do to depend on the brass collet for support, because, instead of driving out the plug, you will only drive the cylinder through the balance. If the lower plug is to be driven out, the counterbore must fit the outside of the cylinder. The next thing is a suitable punch, and if none is at hand it is safer to make one than risk breaking the cylinder; punches are much easier to make than cylinders. Fig. 2 gives a good idea of the right shape, the point *a* being



filed down narrow enough to go into the cylinder, as shown by the end view at *b*. With these appliances and a reasonable amount of care, there is no need *ever* to break a cylinder.

H., *Boston, Mass.*—The errors in Figs. 11 and 12 in the essay on regulators at present in course of publication in the JOURNAL, are due to the engraver. These engravings are designed by the author with the greatest amount of care, and are not to be found in any other work published. The engravings are now being executed under the personal supervision of the author, and may be expected to be more accurate than most engravings of a similar nature are made. The essay will continue a number of months, and will exhaust the subject of Watchmakers' regulators.

A. W. G., *Philadelphia, Pa.*—A difference of opinion exists among watchmakers as to whether the fork of a lever watch should be oiled or not, one party insisting that it should be oiled, and the other maintaining as persistently that no oil should be present on that action. Like every other controversy, there are two sides from which the question may be viewed. If the lever is not set at the proper angle, and if there be an unnecessary amount of friction on the fork, arising from that or any other cause, then a little oil is perhaps beneficial as a temporary remedy. If, however, the action of the fork is perfect, we consider that oil is not only superfluous, but in some instances its presence is injurious.

J. H. S., *Chenango Co., N. Y.*—We have not published a detailed description of the mechanism of Himmer's secondary dial, as was promised in the notice of the late Fair of the American Institute, for the reason that the inventor has not yet had time to prepare the ne-

cessary drawings. We still consider that the construction of the mechanism of these secondary dials is good and reliable. The hands cannot by any possibility move except at the instant the electro magnet attracts the soft iron armature, and when this motion does take place the wheel cannot move more than one tooth at a time. The arrangement Mr. Himmer attaches to the primary clock for closing the circuit is simple and effective, and may be easily attached to any clock. The rubbing surfaces have that sliding motion, which is of such essential importance in keeping the points of contact clean, thereby securing a good contact, and consequently a certain passage of the electric current from the battery to the electro magnet every time the circuit is closed. A secondary dial, or any number of secondary dials placed in the same circuit, will show the same time as the primary clock if everything is properly constructed.

Write to Mr. Himmer for more particular details, or, what would be better, call upon him personally when you are in town. A few minutes' conversation, and a look at the clocks themselves, is worth more than any amount of communications in writing.

R. T., *Boston.*—You can get your dial engraved by Mr. Ledbeter, 83 Nassau St., N. Y. Any special instructions you have to give will be followed to the letter, which is not always the case with engravers, who often either engrave a dial according to some stereotyped pattern, or to suit their own tastes.

R. A., *Newark, N. J.*—There is a method of cleaning glass which may be very well suited for removing slight scratches from watch glasses. Dilute the ordinary hydrofluric acid, sold in gutta-percha bottles, with four or five parts of water; with this wet a cotton rubber, and apply the rubber to the glass pretty thoroughly; afterwards wash the glass till all traces of the acid are removed. The effect of this operation is to dissolve off a very thin portion of the glass, thus leaving a new and bright surface.

C. W. H., *Ky.*—You are mistaken; the little pin in the edge of the going barrel, half its diameter projecting into the edge of the barrel head, is not, as you suppose, for the purpose of compelling the head to be replaced in the same position to insure truth in the revolution of the barrel, although it does subserve that object admirably. It is to prevent the barrel head (upon which the stop work is placed) from being forcibly revolved by over-winding. For if the head was a little loose in its place by reason of the groove in which it rests being a trifle too much undercut, it might be easily revolved by the key after the stop wheels had completed their revolution; this would misplace the stop work in its relation to the main spring. The proper place to set the stop wheels can only be determined by the adjusting rod—applied to each individual spring.

T. T. S., *C. W.*—The readiest way we know of to fit hands, or rachet wheels, to square or round arbors, is, when you have the old hole, run into it a square or round file as the hole requires, place the end of Dennison's (or some other) gauge against the face of the rachet or hand, and see to what division of the scale the point of the file reaches. Now file away the new hole till by trial you find the point.

W. F. H., *Galveston, Texas.*—360° are equal to 24 hours time, therefore the proportion in the present case is this: 360° : 24 hours : : 76° 0′ 12″.

Rule.—Reduce the first and third terms to seconds, multiply second and third terms together, and divide by the first term.

A more simple way is to use the table in Bowditch's Navigator for that purpose, on page 131.

P. R., *Cincinnati, O.*—Your suspicions are correct. Watch cases bearing the London Goldsmiths' Hall mark are not always positive evidence that the watch was made in England. For the past few years gold cases have been made in Switzerland and sent to London, where, through the agency of some parties residing there, they receive the genuine Hall mark, and are returned again to Switzerland to have movements fitted to them, and the watches are sold as genuine English or London made watches. It would appear that the Goldsmiths' Company in London have no power conferred on them at present to ask where the cases were made that are presented to them to receive the mark, neither can they ask what style of movement is to be fitted to the cases, their duties being simply to stamp the cases, if the gold be of the standard quality. Of course, a practical watchmaker, like yourself, can detect the fraud at a glance, but there is no pro-

tection to the public against unscrupulous dealers. We understand steps have been taken to stop this abuse of the London Hall mark, and we hope that some means will soon be devised to remedy the evil; for selling a watch under false pretences is as reprehensible as any other form of swindling.

A. B., *Brooklyn, N. Y.*—The clock in the tower of the building occupied as a Post Office in this city was of German origin, but we understand that the works were removed from the building several years ago. There is a clock over in New Brunswick, N. J., which is said to be an exact counterpart of the one that was in the Post Office. Probably we will include this old clock in New Brunswick in our contemplated description of the tower clocks of the metropolis.

P. F., *Buffalo.*—The powder for polishing jewelry, which you speak of, has already been analyzed. It is found to consist of seventy per cent. of oxide of iron, and thirty per cent. of chloride of ammonium (sal ammoniac). It is made by subjecting iron to the action of hydrochloric acid. After the hydrogen gas has ceased to escape, a solution of the ammoniac is added. The precipitate is filtered at a very low temperature to prevent rapid evaporation.

D. C. G., *Iowa.*—We shall in the June No. publish a complete alphabetical index of the four volumes of the Journal, as there are a great many others that think as you do, that it would be a great convenience. The first volume is now being reprinted, and will be forwarded as soon as ready. The four volumes, bound, will cost $12.

AMERICAN HOROLOGICAL JOURNAL

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For June, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian	Equation of Time to be subtracted from / added to Apparent Time.	Diff. for One Hour.
		s.	M. s.	s.
Sunday	1	68.43	2 27.27	0.379
Monday	2	68.49	2 18.01	0.394
Tuesday	3	68.54	2 8.38	0.409
Wednesday	4	68.59	1 58.40	0 423
Thursday	5	68.63	1 48.11	0.436
Friday	6	68.67	1 37.49	0 449
Saturday	7	68.71	1 26.59	0 461
Sunday	8	68.75	1 15.41	0.472
Monday	9	68.79	1 3.97	0.482
Tuesday	10	68.82	0 52.30	0.492
Wednesday	11	68 85	0 40.40	0.501
Thursday	12	68.88	0 28.28	0.509
Friday	13	68 91	0 15.97	0.517
Saturday	14	68.93	0 3.50	0.523
Sunday	15	68.94	0 9.11	0.529
Monday	16	68.96	0 21.85	0.533
Tuesday	17	68.97	0 34.72	0.537
Wednesday	18	68.97	0 47.66	0.541
Thursday	19	68.97	1 0 68	0.543
Friday	20	68 97	1 13 73	0.544
Saturday	21	68.97	1 26.78	0.544
Sunday	22	68.96	1 39.84	0.542
Monday	23	68.95	1 52.85	0 540
Tuesday	24	68.94	2 5.77	0.537
Wednesday	25	68 93	2 18 61	0 533
Thursday	26	68 91	2 31.32	0.528
Friday	27	68.89	2 43.88	0.521
Saturday	28	68.87	2 56.27	0.512
Sunday	29	68.84	3 8.46	0.503
Monday	30	68.81	3 20.41	0.493

Mean time of the Semidiameter passing may be found by subtracting 0s.19 from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	2 18 19.3
☉	Full Moon	10 10 1.5
☾	Last Quarter	17 3 32.1
●	New Moon	24 9 12.5
		D. H.
☾	Apogee	2 0.5
☾	Perigee	14 2.5
☾	Apogee	29 17.7

Latitude of Harvard Observatory	42° 22′ 48″.1
	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	2 22 44.59	+12 45 15.2	21 40.0
Jupiter	1	9 48 10.40	+14 23 20.7	5 7.2
Saturn	1	20 18 58.32	−19 52 34.5	15 36.1

AMERICAN

Horological Journal.

VOL. IV. NEW YORK, JUNE, 1873. No. 12.

CONTENTS.

ESSAY

ON

WATCHMAKERS' REGULATORS, WITH PRACTICAL DETAILS FOR THEIR CONSTRUCTION.

BY HENRY J. N. SMITH.

CHAPTER V.

THE BARREL.

The construction of the barrel is a subject which requires a greater amount of consideration than is sometimes bestowed upon it. We often meet with regulator barrels which have a considerable more brass put into them than is necessary. The value of this extra metal is of little or no consequence. It is the unnecessary pressure the weight of it causes on the barrel pivots, and the consequent increase of friction, which is objectionable. For this reason the weight of the barrel, as well as the weight of every other part of the clock that moves on pivots, should be made no heavier than is absolutely necessary to secure the required amount of strength. In every instance, except when the diameter is required to be very small, the barrel should be made of a piece of thin brass tubing with two ends of cast brass fastened into it.

Figure 22 is a full-sized sectional view of the ends of a barrel; the diagram on the right is the end where the great wheels rest against, and the one on the left is the other end. The insides of both these ends are precisely the same, but the outsides differ a little. From the diagram it will be observed that there is a little projection near the hole on the outside of the front end. This projection is left with the view of making the hole in the centre longer, and thereby causing this end to take a firmer hold on the barrel arbor. The back end, or the end that the great wheels rest against, and where the ratchet teeth are cut, is shaped precisely like the diagram on the right of Fig. 22.

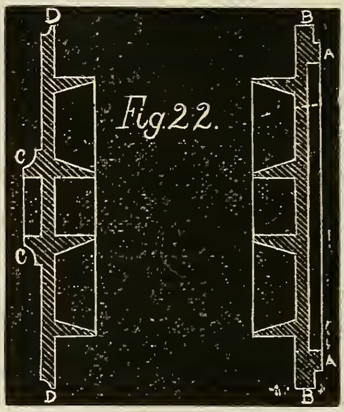
The patterns for these barrel ends should be made without any hole in the centre, and in every way heavier and thicker than is shown in the diagram, because it is difficult to obtain good and solid castings when the patterns are made thin, although it is by no means impossible to make them so. Like all brass castings used for the clock-maker's purpose, they should be carefully hammered, and, although these pieces are of an irregular shape, they can be easily hammered regularly with the aid of narrow-faced hammers or punches, and with the exercise of a little patience. After hammering, the castings should be placed in a wood chuck in the lathe, and the tube which is to form the top part of the barrel fitted easy and without shake on to the flanges, and the other parts of the castings turned down to the required thickness, and a hole a little less than 0.3 of an inch diameter bored in the centre of each before it is removed from the chuck. The tube which is to form the top of the barrel should be no heavier than is just necessary to cut a groove for the cord, and for this regulator it should be 1.5 inch diameter outside measurement, 1.5 inch long, and turned perfectly true on the ends in a wood chuck.

The hole in the front end of the barrel, which is the end nearest to the dial should be broached a little from the inside, and the other end broached a little larger from the outside. The

reason for broaching the holes in this manner is to cause the thickest part of the barrel arbor to be at the place where the great wheels work on, because, in making a barrel for a regulator, it will generally be found that the arbor requires to be thickest in this particular place. The arbor should be made from a piece of fine cast steel a little more than 0.3 of an inch thick, and not less than four inches long. It is always well to have the steel long enough. This steel should be carefully centred and turned true, and of the same size and taper as the holes in the barrel ends. It is not necessary that the barrel arbor should be hardened and tempered, except on special occasions. In most cases it will last as long as any other part of the clock if it is left soft, and it is much easier to make when soft. Before fitting the arbor to the barrel ends it is well to place the ends into the tube that is to form the top of the barrel, because a better fit can be made in this way than when each is fitted separately. When the arbor has been fitted, a good and convenient way of fastening it together is, to use soft solder. It can be easily heated to the required degree of heat with the blow-pipe. A very little solder is sufficient for the purpose, and if the joints have been well fitted the solder will not show when the work is finished. Care should be taken to notice that the solder adheres to the arbors properly. Perhaps it would be well to mention here that, should the clockmaker not have access to a cutting engine with conveniences attached to it for cutting the barrel ratchet after the barrel has been put together, the ratchet should be cut first. Directions for shaping and cutting the ratchet will be given in another chapter.

When the different pieces which constitute a barrel have been fastened together the brass work has next to be turned true, and the grooves cut for the cord to run in. It is best not to turn anything off the arbor till the grooves are cut, because they are usually cut smoother when the arbor is strong. The most important points to notice when turning a barrel is to be sure that the top is of equal diameter from the one end to the other, and that the bearing where the great wheels rest against are perfectly true. Of course the skilful workman will find no difficulty in making every part of his work true and flat, but for the benefit of amateurs—and there are a great many in this branch of the business—I call special attention to these points in turning a barrel, because, if the top of a barrel is of unequal thickness, the weight will pull with unequal force as it runs down, and if the bearing on the end be out of truth, the great wheels will also be very liable to get out of truth, as their position on the barrel is altered by winding the clock up.

The shape of the outside of the barrel ends, as is represented in Fig. 22, will be found to be



good and serviceable. A A is the bearing for the great wheels to rest against; B B is where the ratchet teeth are to be cut. There must be a little turned off the face of B B, as is shown in the diagram, so as to prevent the great wheel from rubbing on the teeth. The space between A A and the barrel arbor is turned smooth with a tool shaped like Fig 1. The hollows at *c c* and *d d*, at the other end of the barrel, are made with a tool which is made on the same principle as Fig. 1, only it is shaped round and made the size of the desired hollow.

Although it is by no means an absolute necessity to have a groove cut in the top of the barrel, yet it is extremely desirable that there should be one, so that the cord may always be guided with certainty as the clock is wound up. It has long been a disputed question whether the cord should be fastened at the front end of the barrel and wind towards the back, or whether it should be fastened at the back and wind towards the front. I am not aware that there is any violation of principle, so far as the regularity of the power is concerned, whether the cord runs one way or the other. I understand it to be solely a question of keeping the

weight clear of the case and the pendulum ball. In ordinary constructed regulator cases this object will be best attained by cutting the screw so that the cord can be fastened at the front of the barrel and wind towards the back; because, in making it in this way, the weight is the length of the barrel farther away from the front of the case when it is wound up, and about the same distance farther away from the pendulum ball when it is nearly run down, than if the cord was fastened at the back end of the barrel and wound towards the front. The cutting of the groove is usually done in a fuzee tool, or a tool specially made for the purpose; but when one of these tools are not available the work can be done in an ordinary screw-cutting lathe.

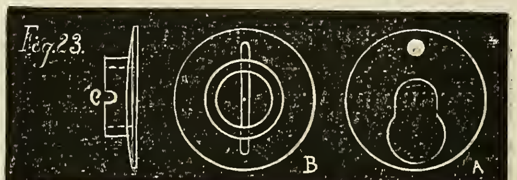
SIZE OF BARREL PIVOTS.

In making the pivots on a barrel it is the usual custom to make the back pivot smaller than the front one but, with all due respect for this time-honored custom, I would direct a little attention to the philosophy of continuing to make the barrel pivots of a regulator in this manner. All readers of the JOURNAL who have been following the friction controversy will at least admit that friction varies with pressure; and also that a large pivot has a greater amount of friction than a smaller one, because the pressure on the sliding surfaces of the revolving body is farther away from the centre of motion in one case than in the other. In regulators where the barrel pivots are of a different size, the effective force of the weight will vary slightly according as the weight is fully wound up or nearly run down. In one instance the pressure of the weight is more directly on the large pivot than it is on the smaller one; and in the other instance the pressure is more directly on the small pivot than it is on the larger one, and when the weight is half wound up, or half run down, the pressure on both pivots are equal.

In the centre pinion and in some of the other arbors of a clock or a watch, it is sometimes necessary to make one pivot considerably larger than the other; but in these cases the difference in the size of the pivots does not affect the regularity of the transmission of the power, because the pressure that turns the wheel is always at the same point. In a regulator barrel, however, the pressure of the cord and weight shifts gradually from one end of the barrel to the other, as the clock runs down, and when the pivots are of unequal thickness the power is transmitted nearly as irregular as if the top of the barrel was slightly conical, and both pivots of the same size. For the above reason, I think that it will be plain to all that in a fine clock both of the barrel pivots should be made of an equal diameter. The front pivot should be made no larger than is absolutely necessary for a winding square, and when we take the fact into consideration that a fine clock with a Graham escapement requires considerable less power to keep it in motion than an eight day marine chronometer does, we may safely conclude that the winding squares of many regulators of the Graham class might be made smaller. A pivot about 0.2 of an inch will secure a sufficient amount of strength. For the reasons mentioned above, the back pivot should be exactly the same diameter, and although the effects of friction will be slightly greater when both pivots are of an equal size, still the force of the weight will be transmitted more regular, which is the object aimed at. Turning and polishing the pivots will be described in another chapter.

WASHERS.

Fig. 23 shows the two different methods of making keys or washers for holding the great wheels on their place on the barrel. A is the



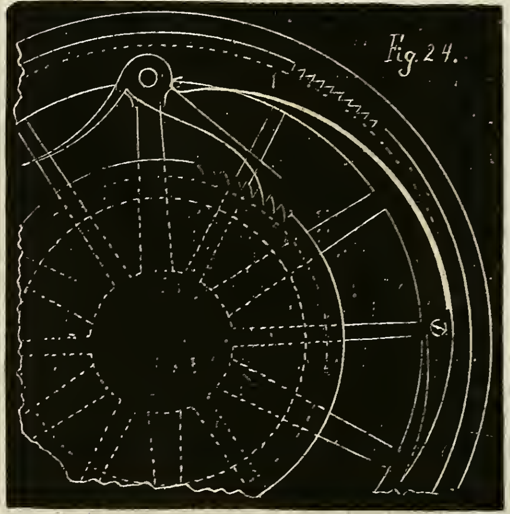
plan most commonly used, and may be made of either steel or good hard brass. Brass is the material oftenest used, but on special occasions they are sometimes made of steel. When making one of this pattern the first thing to be done is to turn a groove in the barrel arbor as deep as the strength of the arbor will admit of, and about one-tenth of an inch broad, or as broad as the brass or steel the key is to be made from is thick. One edge or side of this groove must be a little below the top edge of the great wheel, and the other edge or side should be made as flat and smooth as is possible. A hole is then bored in the centre of the brass or

steel the key is to be made from, exactly the size of the bottom of the groove that has been cut in the barrel arbor. Another hole, the same size as the barrel arbor itself, is then bored as near as the other hole as possible, and the two holes are filed into one, the same as is shown in A. This hole should be made to fit the slit in the barrel arbor free, but without shake. The great wheels are then put on their place, and this key is made to slide over the wheel to the bottom of the slit, as tightly as possible. It must go on tight at first, because, after it and the wheels are polished, it will be free enough; and if it is not, the under side is filed with a smooth file and polished till it is free. The under side of the key should be polished smooth, because if it is rough it will scratch the wheel going on its place. When the key has been fitted tight on the top of the wheel a hole is drilled through it into the wheel for a small screw to go into. This screw ought to have a square head, with its shoulder resting against the wheel, and the small hole in the key made large enough to allow the head of this screw to pass through. A screw made in this manner is best adapted for the work. The key is made round by placing the barrel in a lathe with the great wheel and key on their place, and turning the edge of the key to the desired size.

Another manner of holding the great wheels in their places is shown in Fig. 23; B is a front view, and C is a side view of a collet or washer. A collet of this kind is easily made, and, for a regulator where there is plenty of room, it may always be made of brass. A hole is bored in a piece of brass of the necessary size and quality, and the hole is carefully broached till it fits on to the barrel arbor. It is then placed on a smooth turning arbor and turned in a lathe to the desired shape. It is important that the face of this collet or washer should be perfectly true and smooth, and a very little undercut. Boring the hole for the pin is an important operation, and requires a considerable amount of care, and should be bored a little below the top edge of the collet. The slit across the top of the collet should be made precisely the shape shown at C. This may be easily done by filing it first with the edge of a thin file, and then putting it on its place and broaching it out with a small broach. The brass being softer than the steel cuts first, and a recess for the pin that will wear well is easily formed. In making a collet, too much attention can scarcely be directed to this point.

CLICK WORK.

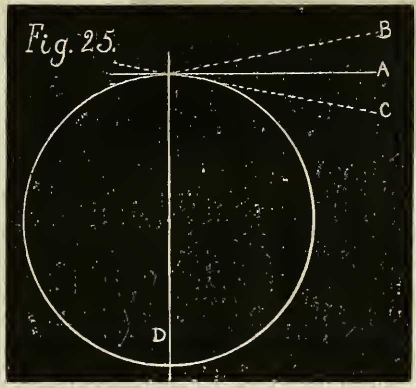
Figure 24 is a representation of the click work. The click is made from a piece of cast steel, and usually works on a screw which



passes through the hole in the centre of motion of the click, and screws into the maintaining power ratchet. It is much safer, however, to make the screw so that it will go tight into the hole in the wheel with its head on the *opposite* side of the wheel from the click, and tap a thread in the hole in the click and make the click work loose on the point of the screw that projects through the wheel. When the click works in this way the screw can never get loose or come out when the clock is being wound up. In making a click in this manner it is best to select a piece of steel slightly thicker than is necessary, and if the point of the click does not come in the desired position when the click is screwed close against the wheel, it can be filed on the under side till the point will turn as far as the teeth of the ratchet. The shape of the click is of little consequence so long as the acting parts are right. It is, however, desirable to select some pattern that has a tail to it, because a tail is very convenient to lift the click out of the teeth when it is necessary to do so. The tail should be made a little thinner than the other part of the click, so that there will be no danger of the cord catching on it.

Click springs for regulators are usually made from hard sheet brass. The brass is first filed to the shape of a straight spring, and then hammered to the necessary degree of hardness. It is best to file the brass to such a thickness that when once it is hammered it will require no more filing, but simply polishing. By doing this we produce a better and a more elastic spring with the same amount of work. When the spring has been polished it is bent to the required curve with the fingers, and rounded a little at the end, with round-nosed plyers, and then fastened to its place on the wheel with one screw and a steady pin. The point of the spring should act at as convenient a distance as possible from the centre of motion of the click. When it acts too far away from this centre of motion there is an unnecessary amount of friction at the point of the spring.

Figure 25 is a diagram designed to illustrate the point the centre of motion of a click should be placed. The circular line is the ratchet; D



is a line drawn through its centre, and A is a line drawn at right angles to D from the edge of the ratchet. Now, if the centre of motion of the click be placed anywhere on the line A, and if the point of the click be at the place where the two lines A and D cross each other, the force of the ratchet will press on the end of the click at a point exactly at right angles to the centres of motion of them both. If the centre of motion of the click be placed on the line C, which is below A, the pressure of the ratchet against the click will have a tendency to make the point of the click, fly up; but if it be placed on the line B which is above A, the pressure of the ratchet against the click will have a tendency to make the point of the click go deeper into the ratchet tooth instead of flying out. For this reason the centre of motion of all clicks should be placed a little above a line drawn from the edge of the ratchet, and at right angles to one drawn through its centre, and the point of the click be where the two lines cross each other.

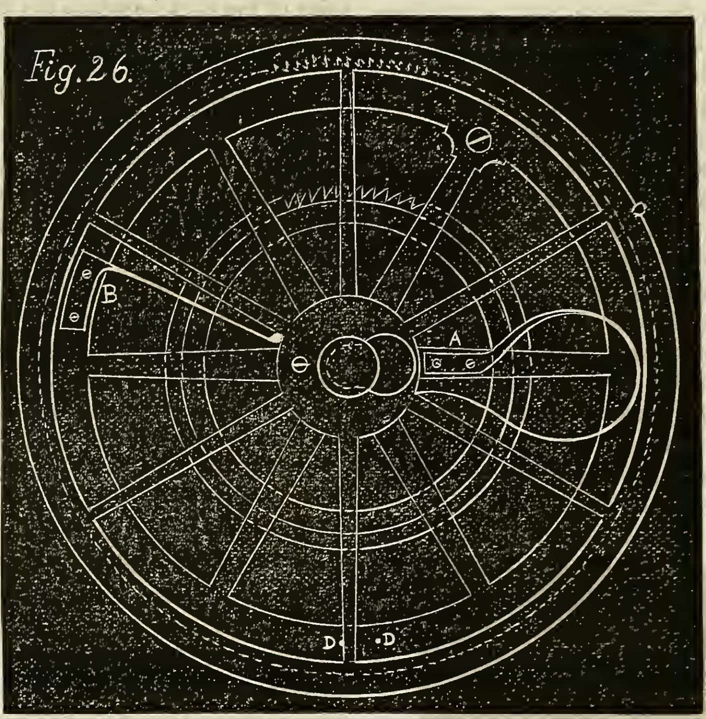
MAINTAINING POWER SPRINGS.

Figure 26 shows the end of the barrel and the great wheels, and also shows the action of two different kinds of maintaining power springs. There are a great variety of maintaining power springs, but the two shown will be sufficient to illustrate the subject. Circular springs cannot be used conveniently when the wheels have arms. B is a straight spring, and is fastened near to the circumference of the maintaining power ratchet; the point presses on the arm of the great wheel near its centre of motion. A spring working in this way requires to be stronger, but it works with less friction than when it is fastened in a way that the point acts farther from the centre of motion of the great wheel. The farther the spring acts from the centre of motion of the wheel, it will exert the greater force, but there will be a greater amount of sliding motion at the point of the spring unless it could be made to bend at the centre of motion of the wheel, which is not an easy thing to do in practice.

Maintaining power springs should always be made from steel, and although brass ones sometimes work well, yet in such an important spring it is always safer to make them of steel. They should be made of a shape that has no sharp corners, because sharp corners are liable to make the spring break easily. The hardening should be done in oil or soft water with the cold chill taken off it. The tempering is done by dipping the spring in oil and then burning the oil off. This is the best way of bringing an irregular shaped piece of steel to a spring temper.

The burning off may be repeated two or three times, and if there be no other heat applied to the steel except the heat of the oil the thin pieces of the steel will never get softer than the thick pieces. If it is desired to blue the spring when it is finished, it may be done without making the spring softer than the oil made it, providing no part of the spring is brought past a blue color.

A, Fig. 26, represents another form of spring, which probably is the best that can be made. It is, however, a little difficult to make. This spring is made from soft steel and bent into shape before hardening. A spring of this shape will be heated more regularly by putting it into a small iron box filled with pounded charcoal. The tempering is done by burning



off oil, as was described in tempering the other spring. Perhaps the best way to fasten a steel spring to the wheel is to use two screws. It is not much more work, and there is no danger of the steady pin coming out when the spring is being hardened.

It is better to use two weak springs than one strong one, because, when one spring only is used, the surface of the hole in the centre of the wheel is pressed against the barrel arbor with a greater force than when two springs are used. Care must be exercised not to make the springs too strong—maintaining power springs being oftener too strong than too weak. The effective force of the springs should never be greater than the force of the weight, or else the springs will either not work at all or they will work imperfectly. It is necessary that the power of the weight should overcome the power of the spring, and when the power of the weight is taken off the clock when winding, the force of the springs is released, and they keep the clock going while it is being wound up. D D, Figure 26, are two pins or small screws. One prevents the weight from pulling the great wheel too hard against the maintaining power springs, and the other prevents the springs from pressing the wheel too far. If these pins are placed at a distance that will allow the great wheel to move a distance equal to two teeth it is enough.

[TO BE CONTINUED.]

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Ed. Horological Journal:

Your correspondent H., N. Y., did not read carefully Mr. Fricker's description of the tool for facing pinions, in the February Number, or he would not have so misunderstood the drawing given. The ring B turns freely upon the screw E, which goes into the handle; it should have been drawn as a repose screw, making the tool, in fact, the same as that described by H., but with the addition of a handle, which simply renders it a little more convenient to use. R. C.

Cleveland, O

Analytical Horology.

BY J. HERRMANN, LONDON.

(*Continued from page* 31.)

THE TRAIN.

The design of this section of a horological instrument being threefold, viz., the division of motive power, its conversion into rotary velocity, and registration of the motions of the balance, our duty will be to elicit the conditions, principle or basis, by which a maximum and uniform transmittance of force, with a minimum reduction of local resistance, is secured; and the mode of procedure will be, not to lay down any fixed principle as a basis, but to examine relative effects by a set of examples of depthing, etc., and to arrive at a conclusion by deduction and analogy, and therefore by a simple practical rule.

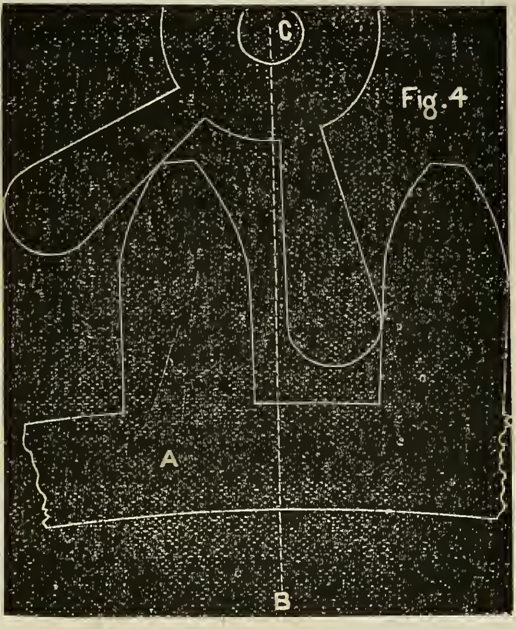
We shall subdivide our subject into three parts, viz.: 1st. Pitching or gearing (which will comprise gearings of various ratios of numbers, proportions and pitch, shape of teeth, etc.); 2d. the relative angular positions of the centres of motions; and 3d, the pivots.

GEARING.

In glancing at a depth we at once observe the heterogeneous elements of sizes, shape and distance. To make this investigation no more complicated than necessary, we shall use the epicycloidal tooth described in Volume II., page 126–8 of the JOURNAL, not as assumed to be correct, but simply *pro tem.*, leaving its examination to a later period.

We shall, therefore, at once take a depth, such as may be found in any old watch, no matter what its nationality, as illustrated in Fig. 4. In order to facilitate the study of this subject, or its reduction to experiments in solid material, we will proceed according to the measurement given in the article quoted. It will be indifferent if the figures are looked upon in the metric or any other system, or if they are taken to represent inches or parts—the ratios being constant in all cases.

According to the above, we represent the primitive radius of our wheel A of 60 teeth, Fig. 4 = 229.2093, and the distance of the centres of wheel and pinion, or the line of centres = 252.1302. The number of pinion leaves, 6. The illustration represents two leaves and two teeth in contact. The contact part or line of centres, measured from pinion centre, is



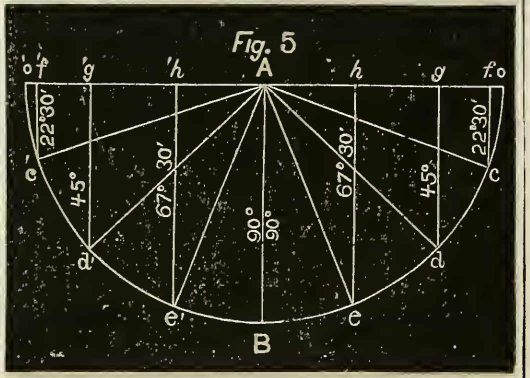
at an angle of 40° with the line of centres C B, and hence the contact before line of centres $\frac{360^\circ}{6} - 40^\circ = 20^\circ$.

It is necessary to leave this example for a time, to take up a sub-illustration to ascertain the result of double contact. The question being, does double contact continue, or is it transitory, and how does either the one or the other occur? After which we will examine the effect, that being our main object.

We have to bear strictly in mind that the wheel is the propeller or driver. Its direction of motion at any one point is the tangent, or is at right angles to its radius of point of contact. The angular measure of the points of contact being 4° 41′ 47″ (see formula page 128, Vol. II., A. H. J.)

From the tangents to pinion contact we get, however, a different result, for their angle varying as their radii, and the latter being at an angle of $\frac{360}{6} = 60^\circ$, the angle formed by the line of directions of the two points of pinion contact is also at this magnitude. But we have to consider the relative directions of the wheel and pinion points of contact, as the conditions on which the answer to our question hinges. These relative motions of the contacts

can be determined by their ratio to their common property, viz., the line of centres, and measured by their respective distance from this line during a constant rotary motion. Let us turn to Fig. 5 for an illustration of these effects. Let A represent the centre of motion or



points of any rotating body, say a pinion; let us trace the relative distance of a point in the circumference, from the line A B during a semi-rotation, which may here indicate the position and direction of the line of centres in a depth *o*. *c*, *d*, *e*, B and *o'*, *c'* *d'*, *e'*, is the arc described by point *o*, and these are also positions of *o* at angles with the semi-diameters A *o* and A *o* of 22° 30'. 45°, 67° 30', 90°, 67° 30', 45° and 22° 30'. We will now notice the ratios of the linear distances passed over by point *o* in its approach to, and receding from A B, during these equal stages of rotary motion.

Let the radius A *o* equal one, (no matter what magnitude that one represents), then the distance passed over by *o* during the first 22° 30' in the line A *o* = *of* = versed sine 22° 30 = .07613, and the distance passed over during the next 22° 30' is equal *f g* on line A *o* = versed sine 45°. Versed sine 22° 30' = .22331. The next stage is represented by *g h* on line A *o*, and is equal.

Versed sine 67° 30—versed sine 45° = .394; and the last stage represented by A *h* on line A *o* equals radius. Versed sine 67° 30' = .6173; the same figures in a retarding ratio express its receding from the line A B on the opposite side. Applying this to the motion of a pinion leaf in rotation to the line of centres, we learn that the distance passed over by a pinion leaf varies in ratio to the angle formed with the line of centres. In other words, it passes over greater rectilinear distance, in equal times, as it approaches the line of centres, and shorter as it recedes from it. The rectilinear direction at right angles to the line of centres expresses the motion in relation to the wheel. As the variations of the ratios of these magnitudes depend upon the magnitude of the angles of rotation, and the rotation of the wheel being only the tenth part of the pinion in their respective rates of rotation = 6°, it follows that the latter will approximate uniformity while the others vary, and hence on those grounds cannot move parallel. But here comes in the curve of the addendum to integrate this difference of relative rotary motion that would otherwise result.

To prove this we will disregard for a moment a physical difficulty in watch pinions, namely, the straight sides, (a difficulty overcome in lantern pinions). and take the relative distance of the extremes of the face of a pinion leaf from the line of centres, and the distance from the corresponding points in the curve from the same line, which distance, if equal, will prove the integration. Taking the radii of wheel and pinion in ratio to our curve delineated as already quoted, Vol. II., A. H. J. = 22.9209 and 229.2093 respectively, the distance of the extreme end of a pinion leaf after a rotation of 40° from line of centre is = sine 40° $\times$ 22–29093 = 14.73, and according to formula (page 128, Vol. II.), this distance of the corresponding point in the curve is = sine 3°35' $\times$ (229.2093 + 5.8187) = 14.73; after a pinion rotation of 60° this distance is = sine 60° $\times$ 22.92093 = 19.85, and by the same formula, the angular position of the corresponding point in the curve being = 4° 42 47", its distance = sine 4° 42' 47" $\times$ 229.2093 + 12.217 = 19.85

This then demonstrates the fact, that by this peculiar curve the relative rotary motion of wheel and pinion are integrated, or, in other words, move through angles in an inverse ratio to their radii. This ratio, though maintained in the lantern pinion, is somewhat perturbed by the solid pinion, for reasons we shall notice when we come to the shape of teeth.

Since we have ascertained by Fig. 5, that a point in a constant rotating circumference moves in an accelerating ratio to, or retarding ratio from, a fixed line; and as we have further seen by the last example, that by the contact

of the curve of the addendum with the end of pinion leaf, the wheel moves through angles inverse in magnitude to the pinion, as their radii, that is, the angle moved through in a given time, by the pinion, is to the angle moved through by the wheel as the radius of the latter is to the radius of the former.

We have the exact condition of one circle rolling over another, which for this definite angle of the circumference is

$$\frac{3.14159 \times 2 \times 22.9293}{6} = \frac{3.14159 \times 2 \times 229.2093}{60}$$

Observing, then, this constancy in their relative rotary motion, and having likewise previously noticed that the linear motion varies in an accelerating or retarding ratio in proportion to the angle of a point from a fixed line, we shall now be able to ascertain the spaces passed over by tooth and leaf in relation to the line of centres, which will solve the question upon which we started as regards double contact in Fig. 4. Supposing that a tooth and the face of a pinion leaf are in contact in line of centres—their radii being in an inverse ratio to their number of teeth and leaves, as is the case in the magnitudes we have taken in our example—and that we then take take the positions of the origin and face of pinion leaf that are adjacent, and also two or three positions in their motion through their respective angles of two teeth and two leaves, which positions accurately correspond in magnitude of distance from the line of centres to similar angular positions past the line of centres, we shall then have this question answered. The distance of the adjacent pinion leaf from line of centres is = sine 60° $\times$ 22.92093 = 19.8501 and of the distance of the origin of the corresponding tooth = sine 6° $\times$ 229 2093 = 23.9589, hence its difference of linear distance = 23.9589—19.8501 = 4.1088. After a rotation of 20° the linear distance of pinion face from line of centres is = sine 40° $\times$ 22.92093 = 14.73329, and the corresponding origin = sine 40° $\times$ 229.2093 = 15. 98884, and hence its difference of linear distance after a rotation 20° = 15.98884—14.73329 = 1.2555 and the decrease of space = 4.1088—1.2555= 2.8533 at this point. After another rotation 20°, the linear distance of pinion face from line of centres = sine 20° $\times$ 22.92093 = 7.839421 and the corresponding origin = sine 2° $\times$ 229.2093 = 7.99929 and its difference = 107.99929—7.83942 = .15977. Since, therefore, under constant rotary motion of wheel and pinion, the relative linear difference of distance of the origin and face of tooth and leaf increases in the same ratio as it decreases before the line of centres, it follows that the moment the contact takes place before the line of centres the wheel is retarded in its course, and the motion of both teeth being synonymous, the increase of linear distance under which contact of curve and face of pinion is maintained is likewise retarded, and hence the contact past line of centres must cease the moment contact before line of centres takes place. Applying now this solution to Fig. 4, we may safely conclude that the double contact is a momentary and not a continuous condition, and that the contact before the line of centres is maintained to the same angular position as the one past line of centres, which ceases at the moment the one before line of centres takes place.

The next question is, what effect has this contact before and after the line of centres, both as regards transmittance of motive power, and as to local resistance?

Let us take another sub-illustration as regards action before line of centres.

Let a c and b d, Fig. 6, be two bars movable about two centres a and b. Their position is so

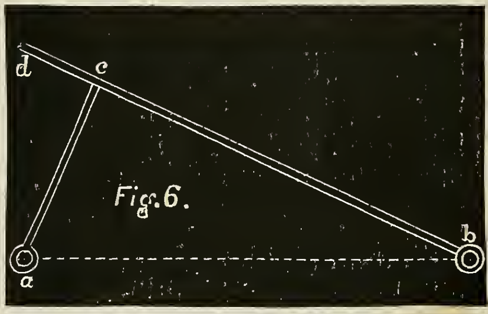
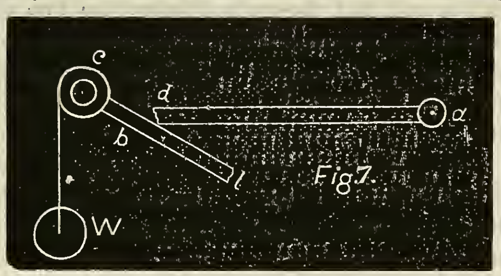


Fig. 6.

adjusted, that b d is resting against the end of bar a c, and at right angles to it. It will require no separate discourse to prove that (stability of parts excepted) no force acting on d b would disturb the equilibrium of these bars. Change, however, that angle a c b, say increase it, and in proportion to its increase, or its approach to a straight line, so will the effect of b d be on a c in turning it about its centres. This effect on a c in turning it about its centre a is therefore proportioned to the cosine of angle a c b.

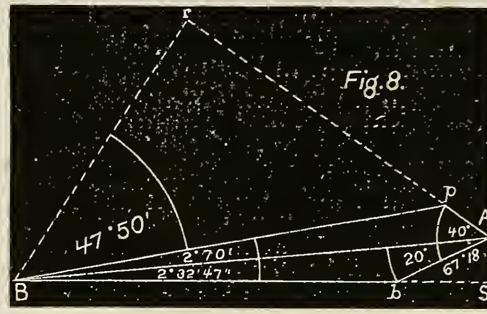
The roughness or smoothness of the parts in contact, or local friction, of which we will make mention at a later period, may relatively increase or diminish the effect, but not the condition. From this we gather that the transmittance of force by contact before the line of centres is inversely proportioned as the angle of the point of contact with the line of centres, and that local resistance increases in proportion to this angle. This fact, then, demonstrates the rule that action before line of centres is an error. Let us now examine the effect of the contact past the line of centres. To do this we will take another sub-illustration.

Let *c b* and *d a*, Fig. 7, be two bars movable about the centre *c* and *a*, a weight W is suspended from the axle *c*, which is propelling



the bar *c b* in a vertical direction. This bar is kept in equilibrio by the other bar *d a*, which is propelled by a force in the opposite direction. Without discussion of the principle of the inclined plane which is here involved, and for the explanation of which I would refer the reader to the lecture on "Economy of Force," published in this Journal. I think this illustration proves itself to a mechanic, that in proportion as the angle *c d a* approaches a right angle, so does the effect of *c d* to turn *d a* about its centre. Since this effect is least when *c b* and *a d* form a straight line, and greatest when approaching a right angle, it proves itself to be in ratio to the sine of the angle. It is conclusive, therefore, that in the action before line of centres we have a minimum transmittance of force, and hence a maximum local resistance, and in the action past line of centres a maximum transmittance of force, and hence a minimum local resistance. In all pitching, the former, therefore, should be avoided, and the latter secured. To elicit the condition on which this depends is our next duty. The question on this point, then, is, why does the action commence before the line of centres, since the small table of ratio given shows a space at the ∠ if 20° equal = .016?

Diagram Fig. 8, will assist us in this inquiry. Let A be the centre of pinion, B the centre of the wheel, and A B the line of centres =



252.1302; A *p* the face of pinion leaf past the line of centres, A *b* the face of pinion leaf before the line of centres, contacts taking place respectively at *p* and *b*; angle *p* A B = 40°, therefore *b* A B = 20°.

The known quantities being A B =252.1302; and B *p* = the radius of pitch circle plus addendum = 229.2093 + 12.216 = 241.4253; and ∠ˢ A ρ, the quantities to be determined, being A *b*, and A *p* and ∠ *p* B A, and ∠ *b* B A. First we will determine the magnitude of ∠ *b* A B.

Producing A *p*, and dropping perpendicular from B meeting it in *r*, this line B *r* is equal sine 40° × 252.1303 = 162.0669. We can now find the magnitude of ∠ *p* B *r* in terms of the secant, by making *r* B the radius. Hence log. secant *p* B *r* = log. 241.4253 − log. 162.0664 + 10 = 10.1516081 = log. sec. 47° 50', and hence ∠ *p* B A=90° − (40°+47° 50')= 2° 10'. By formula (page 128, Vol. 2) ∠ *p* B *b* is found to be 4° 42' 47". ∴ ∠ *b* B A = 4° 42' 47" − 2° 10' = 2830' 47".

Producing B *b* and dropping a perpendicular to *s* from A, this line A *s* = sine 2° 32' 47"× 252.1302 = 11.21765, ∠ *b* A *s* − 90° − (2° 32' 79"+20)=67° 28'. And A *b* = secant 67°× 11.21765 = 29.20986. The magnitude of a pinion leaf of proper ratio to the number being 29.92093, we have then an excess of 29.20986 − 22.9203=6.38993.

It would, however, be against our mode of proceeding to take for granted that the excess of size is the cause of the contact taking place before line of centres. Hence we shall examine in our next (which will not, I trust, be at

such an interval as the present), depths of various magnitudes of lines of centres, with radius of pinion, as found in Fig. 8, in order to ascertain if error of proportion can be neutralized by variation of pitching.

Reminiscences of an Apprentice.

(*Continued from page* 155.)

FINDING THE LENGTH OF A PENDULUM.

"Our journeyman" was greatly delighted because the "Maister" did not apparently understand why it was that a pendulum, in order to keep the same time, required to be made a different length in London than it did in our town, and he embraced every opportunity that presented itself, when the "Maister" was not present, to expose his supposed ignorance on the subject.

One evening as he and I and a number of the young men of our town were walking together on the sea shore, the conversation turned on the new clock that had recently been placed on the front of the church gallery.

One of the young men remarked that he had heard his father talk about it being a clever thing for the watchmaker to make a new pendulum for this clock without knowing the length of the old one. But "Our journeyman" said that it was all nothing; that although he had made the pendulum, he did not understand anything about it, and could not explain why it was that a pendulum required to be made a different length in London than in our town. "And what is the reason?" I asked him playfully; "is it because they make the clocks better in London, and the wheels run easier, that they require a pendulum made a different length to regulate them?" "Yes," says he, quite seriously; "that is one reason; but it is not the scientific one." "And what is the scientific reason?" we all asked. "It is the moon," answered "Our journeyman" solemnly. "The moon!" I asked in astonishment; "what can the moon have to do with a pendulum?" "Aye," says he, "that is all *you* know about it; look at the sea there, is it not the moon that makes the tides?" "Yes," says one of our companions, "and the moon affects the weather." "Yes," says another, "and the moon affects some people's heads." This last remark brought out a universal laugh against "Our journeyman," but he tried to turn the laugh over on me. He said that I was a good illustration of that fact; that I took periodical fits of asking foolish questions, and would not be satisfied with the answers I received from people who knew, but I must have a reason for everything. "Look here," he continued, "nobody can know these things unless they have been in London; and I tell you," he said emphatically, "it is the moon that makes this difference in the length of a pendulum." One of our companions, who had a taste for geometry, thought he saw a connection between the moon, the tides, and the length of a pendulum. He supported "Our journeyman's" assertions, and commenced to make a diagram on the hard sand with the toe of his boot, to demonstrate that as our town was on the sea shore, and as London was some distance back from the sea, that as a natural consequence a pendulum was more affected in one place than the other; and this explanation was considered a satisfactory one by all but myself.

Now, there are a class of people who when they hear anything explained to them that they do not understand, like to listen to high sounding names and learned phrases, and in fact the more mysterious and unintelligible the explanation is, and the more confusing the diagrams are, the better they like it; but, somehow or another, I could never join with these people. As regards the explanation about the moon affecting a pendulum, I did not object to the lines drawn on the sand, and was perfectly willing to listen to all the talk about bisecting and trisecting isosceles and scalene triangles, and to hear him speak about axioms, postulates and scholiums, if he would also tell us at the same time *why* it was that the moon influenced a pendulum so much as to require one only $11\frac{1}{4}$ inches for our town and 7 feet $3\frac{2}{2}\frac{7}{5}$ inches for London. As that point was not made clear enough for me to understand, "Our journeyman" decided that it was another proof of my thick-headedness; that I could not be made to understand anything; that in fact I was nothing but a stupid jackass. I could not, however, conduct myself with the characteristic meekness of that patient animal, and I positive-

ly refused to believe that the moon had such an affinity for pendulums in London as he said it had; but the reader must understand that at this period I had never been in London, and "Our journeyman" had been there two years, which made a great difference.

In many of the old countries boys are kept under a more severe discipline than is generally practised in the United States, and apprentices are not often allowed to practise much familiarity with the "Maister." However, the conversation with "Our journeyman" and our companions on the sea shore had awakened a deeper desire in my mind than before, to be able to understand all the questions connected with the finding the length of the pendulum for the church clock, and I made up my mind to break through the conventional rules and ask the "Maister" more about it, and remind him that he had never said anything on the subject since the first explanation he gave me; and one day when we were at work I asked him if the moon affected the length of a pendulum. "The moon," says he, "what puts that in your head?" "Oh," says I, "'Our journeyman' says that it has a great influence on the length of a pendulum, and makes a difference of several feet between here and London." The "Maister" smiled and remarked jokingly that it was too bad to tell such lies about the moon. I noticed that "Our journeyman" became a little fidgety. His glass would not hold on his eye, but he managed to hold his tongue, no doubt reflecting on the fact that the greatest truths meet with the greatest amount of opposition from people who do not know them, and are not willing to learn.

That afternoon I was called to the "Maister's" bench, and he told me that he was now ready to give me any information or explanation I desired on the subject of finding the length of a pendulum. I asked first if there was any difference in the length of a pendulum between here and London. "Yes, a little," says he; "you know that the earth is not equal in diameter all over; that the distance from its centre is greater at the equator than at the poles, and the force of gravitation varies according to the distance from the centre of the earth's attraction. Gravitation is strongest at the poles, and becomes gradually less as we approach the equator, where its force is a little weaker than at the poles." "And has gravitation anything to do with a pendulum?" I inquired. "Oh, yes, it has everything to do with it, and you must understand all about that before you can comprehend anything about the motion of a pendulum, for the same force that causes a stone or any heavy body to fall to the ground also causes a pendulum to swing." I remarked that I thought it was the clock that made the pendulum swing. "Yes, when the pendulum is once set in motion the clock keeps it going; but if a pendulum is detached from a clock, and the ball is pulled to one side by the hand and let go, it is the force of gravitation that causes it to fall down towards the centre, and the momentum it gathers in falling causes it to ascend nearly as far on the other side; and when the force of the momentum is expended the attraction of gravitation pulls it down again, and the momentum it again gathers in falling forces it up on the other side, and so on, a little less every vibration, till finally the ball stops swinging altogether; and if the material from which it was suspended was not strong enough, the force of gravitation would pull the ball to the ground. The clock maintains the vibrations of the pendulum against the resistance of the air and other obstacles; but it is the force of gravitation acting on the pendulum which regulates the motion of the clock.

"But why is it," I asked, "that a pendulum requires to be a different length here than in London?" "Wait a little; I am about to explain that. If any heavy body is allowed to fall at the equator it will fall through a less space in the same time than it would do at the poles, because the force of gravitation is stronger at the poles than it is at the equator. London is a little nearer to the equator than we are, and consequently the force of gravitation is not quite so strong in London as it is here, and a pendulum requires to be a different length; but the difference is so little that it is scarcely worth mentioning." "Well," thinks I to myself, "according to these statements, we can beat London a little in the force of gravitation, if we cannot do it in anything else;" however, I made no audible remark on that subject, but asked if the moon really had any influence on a pendulum. "Yes, theoretically it exerts a little influence; however, it is doubtful if it be

so much as ever to give you any trouble to make a clock go well." "But what influence does it exert?" I inquired. "Well, it may be explained in this way: If a pendulum is suspended in a delicate manner near to a large mountain, the pendulum, it is said, will not hang perpendicular, but will be attracted a little towards the mountain, because all large bodies attract smaller ones. In a like manner the moon has a tendency to attract the balls of pendulums towards itself, when it shines on that side of the earth where the pendulums are suspended, in the same manner as it attracts the waters of the ocean and causes the tides." "Our journeyman" listened to all this in meek silence, for what benefit was to be derived in arguing questions of this nature with people who had never been in London?

"There is," continued the "Maister," "a most important point on the subject of gravitation, which I wish to impress on your mind, and which will explain the reasons why the number of vibrations a pendulum makes is in proportion to the square root of its length. It is known that if a ball is allowed to fall from an elevated position, it does not approach the ground at a uniform rate of speed, but its motion accelerates as it falls. The body will fall a given distance the first instant of time, and gravity continuing to act upon it will cause it to fall a proportionably greater distance during the next instant, and so on till it reaches the ground. The space through which the body will have fallen in any given number of seconds, increases as the squares of the times. If a body falls sixteen feet in one second, in two seconds it will have fallen four times as far; in three seconds nine times as far; in four seconds sixteen times as far, and so on in the same proportion. In a like manner a pendulum that swings once in half a second must be 4 times as long to swing once in a second; 9 times as long to swing once in $1\frac{1}{2}$ seconds; 16 times as long to swing once in 2 seconds, and so on in exact proportion." At this stage a customer called, and while the "Maister" was waiting on him I slipped round to "Our journeyman" and asked him how it was about the moon now. "Oh," says he, as he blew his breath on a watch frame, "the 'Maister' likes to hear himself talk."

When the customer went away and the "Maister" was at leisure again, he told me that the first time we had talked about finding the length of a pendulum that we were making one to suit a clock that was already made; but suppose a clock had to be made to suit a pendulum of a given length, say 20 inches, how would you proceed to do it? "I don't know," says I. "Well then the first thing to be done is to find out the number of vibrations the 20-inch pendulum will make in a minute. We know that a pendulum 39.2 inches long vibrates 60 times in a minute, and which is in the ratio to the oscillations of the small one as the square root of the length of the small pendulum is to the square root of the length of the large one, and which, we will find, gives 84 vibrations that a pendulum 20 inches long makes in one minute. We have then to construct the wheels and pinions with such numbers of teeth that the scape-wheel teeth will act 84 times on the pallets for one revolution of the wheel that carries the minute hand."

After listening to all this, and going over the figures, I wished that I had paid a little more attention to these things when at school. The most of the things I had heard were also told me there, but at that period I learned and remembered only what I could not help or avoid, and now I was beginning to realize my folly. It was a long time before I could fully understand all I had been told, and comprehend the many other intricate questions connected with the subject. On Sabbaths, when sitting in church, if there was a lull in the services and the ticking of the clock became audible, a train of thought would often be started in my mind which sometimes excluded the more important thoughts of the sanctuary. However, I suppose I was not the first person whose mind has wandered on a pendulum when in church, or reflected on the grand and beautiful studies which are so intimately connected with it.

———o———

☞ In consequence of so much space being occupied with the table of contents several communications that were in type, as well as the answers to correspondents, have to be laid over for the next number.

Close of Fourth Volume.

In accordance with a frequently expressed desire for a more complete Index of the preceding volumes of the Journal, we have prepared them each separately, so that they can be detached and added to their respective volumes, and feel assured that all readers will find it a great convenience. This number closes the Fourth Volume. During the past the Journal has been left to speak for itself, and for the future we shall only say that it is proposed to make it even more worthy of the patronage of the intelligent workman, and urge its present friends to aid us in extending its sphere of usefulness. We again desire to express our deep sense of obligation for the many valuable contributions from practical mechanics, which is a convincing evidence that the influence of the Journal as an instructor is fully appreciated.

During the past four years more progress has been made in the development and construction of fine tools than ever before, and corresponding improvement made in every department of watch work. In the coming volume the bringing into notice of all new tools of merit will be a prominent feature, as the primary object of the Journal is to be a valuable aid to the practical workman.

Our patrons would confer a great favor by each and every one remitting, at once, the amount of subscription for the coming volume, thus enabling us to get our mailing books made up with the least possible delay.

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EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For July, 1873.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be added to Apparent Time.	Diff. for One Hour.
		S.	M. S.	S.
Tuesday	1	68.78	3 32.11	0.483
Wednesday	2	68.74	3 43.54	0.472
Thursday	3	68.70	3 54.66	0.458
Friday	4	68.66	4 5.45	0 443
Saturday	5	68.61	4 15.91	0.428
Sunday	6	68.56	4 26.00	0 413
Monday	7	68.51	4 35 73	0.397
Tuesday	8	68.46	4 45 09	0 382
Wednesday	9	68.40	4 54.03	0.365
Thursday	10	68.34	5 2.55	0.348
Friday	11	68 28	5 10.66	0.330
Saturday	12	68.22	5 18 34	0.311
Sunday	13	68.15	5 25.56	0.292
Monday	14	68.08	5 32.21	0.272
Tuesday	15	68.01	5 38.59	0.252
Wednesday	16	67.94	5 44.39	0.232
Thursday	17	67.86	5 49.68	0.211
Friday	18	67.79	5 54.49	0.190
Saturday	19	67.71	5 58.79	0.168
Sunday	20	67.63	6 2.54	0 146
Monday	21	67.55	6 5.75	0.123
Tuesday	22	67.47	6 8.43	0.100
Wednesday	23	67.39	6 10.52	0.076
Thursday	24	67 31	6 12.03	0.052
Friday	25	67.22	6 12.96	0.027
Saturday	26	67 14	6 13.29	0.002
Sunday	27	67.05	6 13.00	0.022
Monday	28	66.97	6 12.12	0.048
Tuesday	29	66.88	6 10.64	0.074
Wednesday	30	66.80	6 8.54	0.100
Thursday	31	66.71	6 5.81	0.126

Mean time of the Semidiameter passing may be found by subtracting 0s.19 from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	2 11 10.2
☺	Full Moon	9 18 33.7
☾	Last Quarter	16 8 58.3
●	New Moon	23 22 33.8
		D. H.
☾	Perigee	11 17.7
☾	Apogee	27 9.2

Latitude of Harvard Observatory .... 42° 22′ 48″.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION. D. H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE H. M.
Venus	1 3 33 14.80	+15 31 54.8	20 54.3
Jupiter	1 10 5 30.02	+12 48 34.8	3 26.5
Saturn	1 20 12 42.07	− 20 15 53.9	13 31.9